

GRADUATE CATALOG 2020-2021

Policies, Procedures, Academic Programs



GRADUATE SCHOOL POLICIES & PROCEDURES

Student Life and Related University Policies

University Policies for Student Life

All students enrolled at Virginia Tech are subject to student life policies set by the university. The university publication, University Policies for Student Life is available at <http://www.hokiehandbook.vt.edu>. This document is applicable to students matriculated at the Blacksburg campus, as well as those students at branch campuses, higher education centers, or other university owned or leased properties. In addition, information about medical and health related policies and parking are included below.

Physical Examination

All Blacksburg campus students, admitted to the university for the first time, must complete a physical examination form and return it to Student Health Services <http://www.healthcenter.vt.edu/>

Medical Insurance Coverage

The university has contracted with an insurance carrier to offer group coverage for all students at Virginia Tech. For details on levels of coverage and specific limitation, please contact the Student Medical Insurance office in the Student Services Building, 540/231-6226 or 231-6303, or visit <http://www.co.vt.edu/Risk/studenthealthinsr/index.html>. Medical insurance is mandatory for all international students with F-1 or J-1 visa status and their accompanying dependents in F-2/J-2 visa status. Insurance requirements are posted at <http://graduateschool.vt.edu/student-life/immigration-services/immigration-basics/visa-status.html>. Medical insurance is mandatory for all College of Veterinary Medicine students at a minimum of \$100,000 accident and sickness coverage. All students in these two areas must show in writing that they have coverage from another insurance company that is equal to or better than the minimum levels required by the university, or they must purchase the university-sponsored student plan. Review of insurance policies is done by the Student Medical Insurance office. <http://www.co.vt.edu/Risk/studenthealthinsr/index.html>

Required Insurance for Students Traveling Internationally

Virginia Tech's Global Travel Policy (Policy No. 1070) stipulates that all Virginia Tech faculty, staff, and documented representatives traveling internationally for business purposes enroll in an appropriate university-approved Global Travel Insurance program, regardless of any alternative coverage they might have. This requirement extends to students participating in university-supported global education experiences (for credit or not for credit), who are required to carry international emergency medical and assistance services insurance. The approved Global Travel Insurance provider currently is Cultural Insurance Services International (CISI). The CISI plan provides emergency medical coverage and evacuation, security evacuation, and repatriation services. This coverage is provided on a per-person fee basis. The cost for CISI coverage is an allowable international travel expense for university travelers. Among the covered expenses, subject to exclusions and limitations as described in the CISI Schedule of Benefits, are: Charges made by a Hospital for room and board, floor nursing and other services inclusive of charges for professional service and with the exception of personal services of a non-medical nature; provided, however, that expenses do not exceed the Hospital's average charge for semiprivate room and board accommodation. Charges made for diagnosis, treatment and surgery by a Doctor. Charges made for

outpatient treatment, same as any other treatment covered on an inpatient basis. This includes ambulatory surgical centers, Doctors' outpatient visits/examinations, clinic care, and surgical opinion consultations. Charges for medication, x-ray services, laboratory tests and services, the use of radium and radioactive isotopes, oxygen, blood, transfusions, iron lungs, and medical treatment. Local transportation to or from the nearest Hospital or to and from the nearest Hospital with facilities for required treatment. Such transportation shall be by licensed ground ambulance only. Nervous or Mental Disorders are payable a) up to \$10,000 for outpatient treatment; or b) up to \$50,000 on an inpatient basis. We shall not be liable for more than one such inpatient or outpatient occurrence under the Policy with respect to any one Insured Person. Accidental dental charges for emergency dental repair or replacement to natural teeth damaged as a result of a covered Injury including expenses incurred for services or medications prescribed, performed or ordered by dentist. On Call International – A benefit of the Aetna Student Health Insurance plan Students on the Student Health Insurance Plan through Aetna, which is offered to full-time students attending the university, have access to On Call International. For questions regarding On Call International, please contact the Student Medical Insurance Office at (540) 231-6226 or email to SMI@vt.edu. Students who are not enrolled in the VT student insurance plan may purchase the university-approved CISI plan through the Office of Risk Management, phone: (540) 231-7439; e-mail: edouglas@vt.edu. Students should purchase optional coverage prior to leaving the U.S.A. For the link to the CISI application or if more information is needed, please visit the Risk Management website.

Automobiles and Bicycles

Motor vehicles owned and operated by students who drive them on campus and bicycles must be registered with the University Parking Services Office when the vehicle is brought on campus. Parking information and regulations are available at <https://parking.vt.edu>

Graduate Application and Admission

Admission to the Graduate School is contingent upon receipt of a four year (or 3 year degree recognized by the Bologna process) bachelor's degree from a regionally accredited college or university and the presentation of evidence of potential to pursue graduate work. Additional requirements for graduate degrees, beyond those of the Graduate School, vary across academic units. Prior to submitting an application, individuals are encouraged to review the requirements and conditions for admission. Degrees and their requirements, as well as information about which degrees are offered at non-Blacksburg sites, are available at: https://secure.graduateschool.vt.edu/graduate_catalog/programs.htm. Students currently enrolled for graduate degrees at other universities are usually expected to complete their degree requirements prior to their matriculation at Virginia Tech. Applications for admission are reviewed and evaluated by the departmental Graduate Admissions Committee. Major factors considered in this evaluation are scholastic record, professional experience, letters of recommendation, and as appropriate, scores on standardized tests. Individual departments may have additional admission standards beyond those set by the Graduate School. Applications and all related materials for admission should reach the Graduate School Office at least eight weeks before the beginning of the semester in which enrollment is requested. For financial assistance information, visit <http://www.finaid.vt.edu>. Applications for admission should be submitted on-line at: <https://graduateschool.vt.edu/admissions/how-to-apply.html>. If this is not possible, a printable application also is available.

Credentials

Applicants should submit copies of their transcripts with the online application. Unofficial copies are acceptable for review by the department and Graduate School. Upon admission, official transcripts should be sent to the Virginia Tech Graduate School. If the official transcript submitted for admission does not show bachelor's degree completion, the applicant will need to later supply another official transcript showing that the degree has been awarded/conferred. Letters of reference can be submitted on line (preferred) or sent directly to the academic department. Individual departments may require applicants to submit the results of the Graduate Record Examination (GRE). For applicants to the Pamplin College of Business, the Graduate Management Admissions Test (GMAT) is required. Please request that GRE or GMAT scores, if applicable, be sent to Virginia Tech. The Educational Testing Service Institution Code for Virginia Tech is 005859. Please visit academic department websites for other departmental requirements such as resumes, vitas, portfolios, etc. All credentials submitted in support of an application become the property of the university.

International Applicants

Legal Status and Financial Certification All international students must hold valid non-immigrant visa status to enroll at Virginia Tech. Prior to the issuance of certificates of eligibility to apply for the appropriate visa, all international students must submit an Immigration Information Form. The following link provides the Immigration Information Form, Affidavit of Support, and Financial requirements and general instructions: <https://graduateschool.vt.edu/student-life/immigration-services/new-student-guide.html>. The Immigration Information Form collects (1) information required for issuance of visa eligibility documents and (2) information that demonstrates that a student has sufficient financial resources for at least the first year of education. International students in F-1 and J-1 visa status and their accompanying dependents are required to carry health and accident insurance approved by Virginia Tech. International students who have been admitted and have shown proof of having sufficient funds to cover their educational and living expenses for at least one year are issued visa eligibility documents (I-20 or DS-2019 forms) by the Graduate School. Evidence of English Proficiency International applicants are exempt from demonstrating English proficiency if they have graduated from an accredited university where English is the language of instruction or if they are U.S. permanent residents ("green card" holders). International applicants may demonstrate English proficiency by submitting scores from the Test of English as a Foreign Language (TOEFL) or the International English Language Testing System (IELTS). A minimum TOEFL score of 550 on the paper-based test (PBT) or 90 on the internet-based test (iBT) is required for consideration of the application. On the iBT, subscores of at least 20 on each subtest (Listening, Speaking, Reading, and Writing) are required for admission. A minimum IELTS score of 6.5 is required for admission. Some departments have higher TOEFL or IELTS score requirements than those set by the Graduate School. Students who anticipate appointment as Graduate Teaching Assistants are expected to have scored 25 or greater on the TOEFL Speaking subtest. GTA appointment of a student scoring 20-24 on the Speaking subtest should be justified explicitly within the particular academic unit; appointment of a student scoring below 20 on the Speaking subtest requires justification with the Graduate School. For more details, see <http://graduateschool.vt.edu/admissions/how-to-apply/testing-requirements.html>. Attending at Extended-Campus Locations International students in F-1 or J-1 visa status may pursue graduate degrees in Blacksburg or at the extended-campus in the National Capital Region (NCR). Questions regarding enrollment eligibility at the NCR

location should be directed to the International Graduate Student Services office of the Graduate School in NCR at 703/538-3743, GSSONCR@vt.edu; <http://www.ncr.vt.edu/>. Requirements for Assistantships and Employment International students in F-1 or J-1 status who obtained admission into a degree program are eligible for consideration by the academic departments for assistantships and in-state tuition scholarships. Part-time employment on campus is subject to federal regulations governing employment of student (F-1) and exchange visitor (J-1) visa holders. Blacksburg students should contact the International Graduate Student Services office of the Graduate School at 540/231-8486, igss@vt.edu; National Capital Region students should contact 703/538-3743, GSSONCR@vt.edu.

Admission Categories and Graduate Student Classifications

Students are admitted or classified in one of the following categories:

Regular Admission

Regular Admission to a graduate degree is open to an applicant whose grade point average (GPA) meets or exceeds the 3.00 required by the Graduate School for the last half of the credits earned for the undergraduate (bachelors) degree, and whose academic background meets the requirements of the admitting academic unit. A graduate degree, or at least 12 credits of graduate coursework taken post-baccalaureate, while in graduate status, will supersede the undergraduate record in evaluating credentials for admission.

Provisional Admission (Master's only)

Provisional Admission to a graduate degree is open to an applicant whose GPA is below the 3.00 required by the Graduate School, but generally not lower than 2.75, who has other experience or qualifications that demonstrate potential to undertake graduate study, and whose admission is requested by the admitting academic unit. Provisionally admitted students are regular degree-seeking students with the condition that they must earn at least a 3.00 GPA for the first 12 graduate credits they attempt. If a 3.00 GPA is not earned in the first 12 credit hours attempted, the Graduate School will consult with the academic unit to determine whether the student should be allowed to continue for one additional semester on probationary status (see Academic Progress, Probation). Appropriate coursework taken while on Provisional status may be included on the Plan of Study for the student's graduate degree at the discretion of the student's Advisory Committee.

Conditional Admission

An applicant whose academic background is deficient in some aspect, but who otherwise meets minimum GPA qualifications for admission (Regular or Provisional) may be granted "conditional" admission. The admitting academic unit specifies and informs the conditions of admission to the applicant and the Graduate School by letter prior to applicant matriculation. The academic unit notifies the Graduate School when the conditions have been met.

Non-degree Status

Non-degree status is open to an applicant who qualifies for admission to the Graduate School in Regular status (i.e., who has a 3.00 GPA or better for the last 60 credit hours of undergraduate study) but who does not wish to, or cannot be, listed as a degree candidate for one of the following reasons: (a) does not currently desire to work toward a graduate degree; (b) desires to transfer the credits for use toward a graduate degree at another institution; or (c) there currently is no higher degree available at the university other than the one the applicant

currently holds in the department or field of study. Official transcripts of the undergraduate degree are required for admission to this status. The university places no limits on the total number of credits that may be taken while in Non-degree status. Credits earned by students in Non-degree status may be used in meeting degree requirements, if they are appropriate for inclusion, in the Plan of Study if the student is later admitted to a graduate degree. Graduate students in Non-degree status are not eligible for graduate assistantships. International Exchange Students in J1 status only may hold Non-degree status for up to two semesters (note that TOEFL score requirements do apply).

Commonwealth Campus Status

Commonwealth Campus status is open to an applicant who holds an earned bachelors or higher degree from a regionally accredited U.S. university. Examples of students who seek admission into the Commonwealth Campus program include those who (a) may qualify for regular admission but do not currently wish to work for a graduate degree; (b) do not qualify for admission because of a poor undergraduate record and wish to improve their credentials; (c) need to update their academic credentials after several years of professional experience or (d) require graduate courses for professional certification. International students in F1 or J1 visa status are not eligible for Commonwealth Campus status. However, some other types of visa status may allow non-degree enrollment (note that TOEFL or IELTS score requirements do apply). Students applying for Commonwealth Campus status must complete the Application for Admission and submit a transcript (unofficial is sufficient) or a copy of their diploma for the highest degree attained. Students in Commonwealth Campus status are not eligible for graduate assistantships. Commonwealth Campus students are limited to 12 credits of course work while in this status. Students may not earn a graduate degree while enrolled in Commonwealth Campus status. If a Commonwealth Campus student wishes to enter a degree program, the Application for Admission to that degree needs to be filed early in the semester prior to the desired semester for degree entry. If the student is accepted to a degree, a determination of the applicability of any courses taken while in Commonwealth Campus status, to a graduate degree, will be made at the time of submission of the Plan of Study for the degree.

Graduate Certificate Status

A qualified student who wishes to enter Virginia Tech to obtain a graduate certificate, without being enrolled in a degree program, may apply for graduate admission to Graduate Certificate status. Such applicants should submit concurrently an Application for Admission and a Graduate Certificate Application http://graduateschool.vt.edu/content/dam/graduateschool_vt_edu/GAAPforms/Application_Certificate.pdf. The Graduate School requires a GPA of 3.0 for admission to Certificate Status and official transcripts must be submitted. Note that students pursuing a degree and a certificate simultaneously are classified in their degree program. Up to 50% of the credits used toward a certificate may be used in meeting degree requirements if they are appropriate for inclusion on the Plan of Study for the degree. No credits can be triple-counted.

Visiting Graduate Student Status

A graduate student in good standing at another university may be permitted to take graduate courses by submitting a Visiting Graduate Student Application form, available at http://graduateschool.vt.edu/content/dam/graduateschool_vt_edu/GAAPforms/Application_for_Visiting_Graduate_Student-1.pdf. Enrollment as a visiting graduate student is limited to one calendar year or 18 credit

hours.

Eligibility of Faculty/Staff for Graduate Degrees

Teaching and research faculty of the rank of assistant professor or above shall not become candidates for degree or be awarded graduate degrees from this university. The Provost's Office may be requested to waive this policy for an individual following successful appeal to the Commission on Faculty Affairs. Staff and administrative/professional faculty may become candidates for graduate degrees with approval from the academic program, the university employer, and the graduate school. To receive approval, candidates must address conflicts of interest, time, and commitment. Supervisors of these candidates should abstain from chairing and/or serving on the candidates' graduate committees to avoid potential conflicts of interest. The Conflict of Interest Agreement form for staff and administrative/professional faculty seeking a graduate degree may be found

here: https://graduateschool.vt.edu/content/dam/graduateschool_vt_edu/misc-forms/vt-employee-studentconflict-of-interest-agreement.pdf.

Undergraduates Taking Graduate Courses

Seniors Students in their senior year, with a 3.0 or better GPA, may enroll in 5000-level courses satisfying undergraduate degree requirements within their department with the permission of the course instructor and the Department Head. Should the student become a graduate student, these courses may not be used on the Plan of Study for a graduate degree. Dual Student Status Seniors in a bachelor's degree, who have a GPA of 3.0 or better may be eligible for Dual Status during the final semester of their undergraduate degree. To obtain this status, students must file an application for the master's degree and the Accelerated Undergraduate/Graduate Degree and Course Designation Form (for obtaining Dual Status) (http://graduateschool.vt.edu/content/dam/graduateschool_vt_edu/GAAPforms/Accelerated_Undergraduate_Graduate_Status.pdf). The department reviews the student for master's acceptance and, if this is recommended, indicates on the Admission Analysis form that the student will be accepted for Dual Status for the final semester of the undergraduate degree. This acceptance must occur prior to the final semester of the undergraduate degree. Graduate coursework taken during the semester of dual registration may only be designated for use in the graduate degree when it is not used to meet bachelor's degree requirements (i.e., each course taken during the final semester is specified as being for either the bachelor's or the master's degree). A grade of B or higher must be earned in each Dual course to be placed on the graduate transcript. Combined Student Status (Architecture Only) This status is reserved for qualified students in the bachelor of architecture program who: (a) are within 24 semester hours of graduation; (b) are proceeding toward the two-year master's program in architecture; and (c) have at least a 3.0 GPA for the last two years (60 credit hours) of undergraduate studies. Combined students are permitted to take graduate courses. Accelerated Undergraduate/Graduate Degree Programs In accordance with the policy of the Commission on Graduate and Professional Studies and Policies for accelerated undergraduate/graduate degree programs, "each graduate degree program wishing to offer one or more accelerated undergraduate/graduate degree programs must submit a written description of their program to the Graduate School for review and approval before students may be admitted hereto." Consistent with Graduate School policy, the standards for each program must meet the minimum requirements but can exceed these (e.g., GPA, fewer courses to be double counted). These regulations include the following: Students must be accepted into the program prior to the beginning of the semester in which they would enroll in courses to be used on the

accelerated program. Students qualifying for the program must be in the last 12 months of their undergraduate degree. A minimum GPA of 3.3 is required at the time of acceptance to the program. Once completion of the undergraduate degree has been verified, students accepted into this accelerated program will be classified as regular graduate students. A maximum of 12 credits of graded coursework may be used in the program. No more than 6 of the double-counted credits may be at the 4000 level; all others must be offered for graduate credit. A grade of B or higher must be earned in each course to be double counted. Courses must not be taken pass-fail if a graded option is available. Programs that intend to accept students into an accelerated graduate program must submit a proposal to the Graduate School that includes the following: Accelerated program(s) to be offered. These can include programs designed for VT students as well as non-VT students from U.S. institutions or in partnership with international institutions. Graduate degrees included - master's or doctoral degrees, or both. Admission criteria and application materials required, including but not necessarily limited to student status, minimum GPA requirement, statement of motivation and career objectives, student's experience and qualifications as reflected in a resume, a portfolio, and/or letters of reference. The number of credits to be double counted towards undergraduate and graduate degrees. Process for identifying potential students and faculty advisors, and for mentoring during program. Tentative listing of courses that the department expects to be used for graduate plans of study for students in the program. Other conditions or aspects of the proposed program as appropriate.

Enrollment and Registration Procedures

Course Enrollment and Changes in Enrollment

Registration Registration (Course Request; for continuing students occurs during an eight-day period in the middle of each semester during which current students may request and be registered electronically for classes for the next semester. Registration for new students begins prior to the start of the new semester. For registration procedures, see <http://www.registrar.vt.edu/>. Schedule Adjustment Students may adjust their schedules on a space available basis using web DROP/ADD (available through HokieSPA <http://www.hokiespa.vt.edu>), an electronic schedule adjustment program. The Add Period is restricted to a short period at the beginning the semester, the Drop Period lasts for a larger proportion of the semester; deadlines for these electronic transactions that can be done by the student are published in the Timetable of Classes for each semester, see Important Dates and Registration Information

at: https://banweb.banner.vt.edu/ssb/prod/HZSKVTSC.P_DisRequest. Force-Add A Force-Add form permits enrollment in a class, over the set capacity for that class, within the Add period. This transaction is done with the "force-add" form in the department offering the course, and requires the instructor's (or, in some departments, departmental) permission. Force-adds are processed by the department offering the course during the Add Period in the first week of classes of each semester. Late Adds and Drops Late Adds and Drops: In unusual circumstances when adjustments to the student's schedule are needed after the last date to add or drop a course, permission is required from the instructor, the student's advisor and a graduate dean (see the current Timetable for deadline dates). The request for the Late Add or Drop and an explanation of the extenuating circumstances necessitating the late change should be submitted to the Dean's office by the student's Advisor or the Graduate Program Director of the department. Graduate Withdrawal Course withdrawals late in the semester: If a late withdrawal from a course (after the Drop period for electronic drops) is approved it will be designated as a Graduate Withdrawal (WG on the transcript) and

will not carry a grade penalty; this option is only allowed prior to the Friday of the last week of classes for the semester. Use this form: [http://graduateschool.vt.edu/content/dam/graduateschool_vt_edu/GAAPForms/Graduate_Course_Withdrawal_\(WG\).pdf](http://graduateschool.vt.edu/content/dam/graduateschool_vt_edu/GAAPForms/Graduate_Course_Withdrawal_(WG).pdf) If a student wants to Withdraw from all courses for the semester or if a student who is enrolled for a single course wants to drop that course, a Resignation/Withdrawal form (see below) must be submitted to the Graduate School for approval and to the Registrar's office by specific deadlines. Resignation/Withdrawal A student may resign/withdraw without academic or tuition penalty by completing an official Virginia Tech Resignation/Withdrawal form on or before the first day of the semester/summer session (for relevant dates, see the Registrar's Office website: <https://www.registrar.vt.edu/resignation-withdrawal.html>). The Student Withdrawal/Resignation Form is available at http://registrar.vt.edu/content/dam/registrar_vt_edu/documents/Updates/forms/Student-Withdrawal-Resignation-Form.pdf. Resignation/withdrawals received at the Registrar's office after 5 pm on the first day of the semester result in partial tuition and fee charges (see Bursar's office refund policy <https://www.bursar.vt.edu/students/refunds.html>). Resignation/withdrawal after the specified date for withdrawing without grade penalty requires permission of a Graduate Dean and is only permitted because of extenuating circumstances. The student's grade report and transcript will show that he/she was enrolled for the term and that he/she resigned on the specific effective date. Resignation/withdrawals may have consequences for assistantship and scholarship awards as well as visa status, so these considerations should be investigated prior to completing the forms. Resignation/withdrawals do not affect the student's ability to enroll in the subsequent semester. The Graduate School (VP/Dean and Associate Deans) reviews and approves the appropriate date of the withdrawal. For medical withdrawal with official Schiffert review, the date recommended by Schiffert or Cook is accepted. For withdrawal or resignation from the university (all courses in a given semester, consideration is given to the length of time the student was enrolled in the course and utilized university (faculty, staff) time and resources, the date the form was submitted and the percentage of refund allowed by the Registrar's office, and the reasons for withdrawal. Decisions by the Graduate School can include a retroactive withdrawal or adjustments to the specified deadlines for refund. Student responsibility for enrollment Student responsibility for enrollment. Each student is responsible for verifying his/her enrollment in courses and for making any changes in that enrollment. Students should check their enrollment in specific courses during the first week of classes of a semester (the Add Period) when any corrections can be made electronically. Faculty cannot add or drop students from their rolls and cannot add or drop a student by including or removing his/her name on the final grade sheet.

Continuous Enrollment

Unless on approved in absentia or leave of absence status, graduate students in degree programs must be registered continuously at VT during the academic year (fall and spring semesters) and pay the prescribed tuition and fees (See Policy PPM 291). Students working on research/scholarly activity toward their thesis or dissertation should enroll in the number of credit hours that reflects the extent of a student's study or research activity. The minimum enrollment is for 3 credit hours at VT except in the case of a student who qualifies for Start of Semester Defense Exception. If the student holds a Graduate Assistantship, scholarship, or other form of financial support, the enrollment requirement is typically set by the conditions for that support. Students on Graduate Assistantships must be enrolled for a minimum of 12 credits per semester (see Academic Eligibility to Hold a Graduate

Assistantship). Individual graduate programs may seek approval from the Graduate School to temporarily or permanently exempt some or all of their students from this policy. Such exemptions may be granted to programs that are dominated by distance learning, to programs that are specifically directed at part-time students, to salaried employees qualifying under Policy 4800, or for other appropriate reasons. Graduate students who need to break continuous enrollment can do so by applying for a leave of absence or by participating in programs and activities approved by the Graduate School that require absence from the University (in absentia status). Students who fail to follow this process will be resigned from the university by the Graduate School, and will then need to apply for readmission in order to continue their studies. Readmission requires a positive recommendation from each student's home academic unit, and is not guaranteed.

Leave of Absence

Students sometimes experience situations in which they cannot be continuously enrolled (e.g., health, family emergency, change in parental status, military service, financial hardship, personal or academic reasons, or other reasons). A student may request a leave of absence to suspend activities associated with course work or thesis/dissertation research (see Policy PPM 292). Students on leave of absence are not entitled to use University resources not normally available to the public or alumni (e.g., may not consult with advisors or work on courses or research). The Leave of Absence Request Form must be submitted two weeks before the beginning of the semester for which the leave is requested. The leave of absence must be approved by the student's advisor and the Department Head or Graduate Program Director for the department before submission to the Graduate School. If the leave of absence request is approved, the continuous enrollment requirement will be relaxed during the period of leave. The Leave of Absence form indicates when the student will return to the program and any conditions the department or the Graduate School may stipulate for the student's readmission within that time. Leaves of absence may be granted for up to one year at a time. If a leave longer than one year is required, students will need to apply to the Graduate School for readmission. International students should consult an immigration advisor in the Graduate School before requesting a leave of absence.

Registration at the Time of Examinations and for Degree Completion

Graduate students must be registered at VT for at least the minimum number of credits (3 credit hours) in the semester or summer session when they take an examination required by Graduate School Policies and in the semester when a degree is completed (see Continuous Enrollment). Students who have a thesis/dissertation ready for defense by the beginning of a semester, may schedule that defense early in the semester and qualify for Start of Semester Defense Exception (SSDE, 1 credit); see Start of Semester Defense Exception under Examinations and see Dates for Degree Completion at: <http://graduateschool.vt.edu/academics/what-you-need-to-graduate/deadlines-for-academic-progress.html>. Students are not required to be enrolled for the purpose of certificate completion alone.

Readmission

When a student has not been registered for more than one calendar year, an Application for Readmission <http://graduateschool.vt.edu/admissions/how-to-apply/readmission.html> is required whether or not the student has been on a formal Leave of Absence. The Readmission process requires a review of the student's progress and of the Plan of Study to determine

what changes, justification of old course work, committee changes or other conditions may be required for readmission to the degree (the forms required for these processes are at: <http://graduateschool.vt.edu/academics/what-you-need-to-graduate/forms.html> The minimum enrollment is 3 credits.

Changes of Status

A change from one type of degree status to another, while remaining in the same major, requires a Change of Status form http://graduateschool.vt.edu/content/dam/graduateschool_vt_edu/GAAPforms/Change_of_Degree_Status.pdf. An example of a status change is: Master's to Ph.D. in the same major. International students in F1 or J1 status should consult with the international advisors in the Graduate School for the proper SEVIS changes. For departments where the non-thesis option is available, a master's degree candidate is allowed to change status from the thesis to the non-thesis option (or vice versa) only once. The Thesis Option Change Form http://graduateschool.vt.edu/content/dam/graduateschool_vt_edu/GAAPforms/Thesis_Option_Change_Request.pdf requires accompanying documentation from the department that verifies the appropriateness of the change of status. A change from Commonwealth Campus or Non-degree status to Master's or Ph.D. requires an Application for Admission and submission of official transcripts (if these weren't previously submitted) and all other required application materials (<https://graduateschool.vt.edu/admissions/how-to-apply.html>)

Change of Graduate Program

Change of Graduate Program (between departments) A change from a degree in one graduate program/department to a degree in another program/department requires the approval of the Graduate Program Director or Department Head of both the old and the new programs and the Graduate School. http://graduateschool.vt.edu/content/dam/graduateschool_vt_edu/GAAPforms/Change_of_Graduate_Program.pdf Students wishing to change programs should consult with the department they wish to enter to determine the likelihood of acceptance prior to beginning this process. The department the student wishes to enter may see the original application materials by making a request to the Graduate School and may request additional materials from the student.

Change of Campus

Students who wish to study at a different campus, but remain in the same major, should submit a Change of Campus form http://graduateschool.vt.edu/content/dam/graduateschool_vt_edu/GAAPforms/Change_of_Campus.pdf International students in F1 or J1 status should consult with the international advisors in the Graduate School for the proper SEVIS changes.

Simultaneous Graduate Degrees

Students wishing to work toward two graduate degrees in different departments/programs should submit an Application for Simultaneous Degree Approval. http://graduateschool.vt.edu/content/dam/graduateschool_vt_edu/GAAPforms/simultaneous_degree.pdf See also Credit Hour Requirements; Simultaneous Degrees.

In Absentia Status

Graduate students in good standing who for academic reasons need to spend an entire Fall or Spring semester away from campus can apply for and be granted in absentia status (see Policy PPM 293). In absentia

status is granted for work that is directly related to a student's academic course of study and that is integral to her or his degree. Examples include field research, clinical internship, or laboratory work with research collaborators at remote institutions. In absentia status is approved by each student's home academic unit and then by the Graduate School. During each Fall or Spring semester in absentia, students must register for one credit hour. To qualify for in absentia status, students must be stationed a minimum of 50 miles away from Blacksburg, and must not work on or in conjunction with any of Virginia Tech's satellite campuses and facilities. Students can remain in absentia for two consecutive semesters, but must then return to residency at the University for a minimum of one semester. Exemptions may be granted by the Graduate School when longer periods of absence are required. In absentia status is not available to students who have not adhered to the continuous enrollment requirement, are supported by an assistantship, or are participating in an exchange program or dual degree program with an officially designated partner institution.

Graduate Cooperative Education Program

See Presidential Policy Memorandum 27

at <http://www.policies.vt.edu/policymemos/PPM27.pdf> All students are expected to be making reasonable academic progress towards a degree while participating in a Graduate Cooperative Education Program. The responsibility for monitoring students' academic progress is shared by their department and the Graduate School. Someone in the Graduate School shall be appointed to represent the University in matters related to the Graduate Cooperative Education Program. This person shall sign all graduate co-op agreements between the participating firm and the University. [Note: Contact an immigration advisor at the Graduate School.] The department or degree conferring unit shall be the prime unit in negotiating all graduate co-op agreements. The rights and needs of the University will be protected in all agreements by review of the agreement by the University's representative. All graduate cooperative programs must be approved by the department or degree conferring unit. As consistent with these specifications, departmental policies with regard to registration, course load, course number, course credit, program of study, and advising will remain the province of the cooperating department. Nothing will be included in the agreement that will intrude upon the privileged relation between the faculty advisor/major professor and his/her student. All students involved in graduate cooperative programs shall be enrolled in the one-credit course "Graduate Cooperative Education Program," GRAD 5944 (master's students) or GRAD 7944 (doctoral students), and pay the appropriate fee while on co-op assignments. See additional details at <http://graduateschool.vt.edu/student-life/immigration-services/employment/cooperative-education-program.html>

General Academic Information

Grading System

Assignment of grades is the responsibility of the course instructor. The university has adopted the following grading system: Letter Grade Numerical Value (GPA) A 4.0 A- 3.7 B+ 3.3 B 3.0 B- 2.7 C+ 2.3 C 2.0 C- 1.7 D+ 1.3 D 1.0 D- 0.7 F 0.0 Grades in all courses, assigned one of the letter grades above, are calculated into the overall GPA on the transcript. An additional GPA is calculated for the Plan of Study for each graduate degree. There are, in addition to the above grades, the following grades that do not calculate into the GPA: "I" (Incomplete), "P" (Pass; performance of C- or higher when enrolled for the P/F grade option), "X" (a temporary grade for the first semester in those courses that continue across more than one semester; "EQ" (Equivalent Credit, a

"pass" for research or project/report credit); "RG and RP" (Repeat Graduate grades) and "NR" (grade Not Recorded, indicating the instructor did not enter a grade). The "NG" (No Grade, assigned when the student has not done any of the work for the course) and the grade "F" on a course taken Pass/Fail calculate as 0.0 in computing the GPA.

Grade for Thesis/Dissertation/Major Paper

Research toward a thesis, dissertation or major paper (the last is generally designated as Project and Report credits) is assigned equivalent credit hours (EQ grade) when satisfactory progress has been made. The "NG" grade can be given when progress on a thesis or dissertation has not been satisfactory.

Incomplete, X, NG and NR Grades

An Incomplete ("I") grade, which is not calculated in the GPA, may be given when the requirements of a course have not been completed because of illness or extenuating circumstances. It is at the discretion of the instructor whether the circumstances warrant the assignment of an Incomplete. Incompletes should be removed, by completing the course requirements, as soon as possible. Departments should set policies for the time allowed for removal of "I" grades and the number of "I" grades that are allowed by students in their programs. Grades of "I" may be removed during a period when the student is not enrolled at the university. Grades of "X" are assigned initially to students in a course that extends over more than one semester and are removed when the final grade for the course is entered. Graduate degrees cannot be completed until all "I", "X", "NG" and "NR" grades on the Plan of Study have been converted to a passing letter grade (i.e., a C- or better for courses with the A/F grading option, a P for courses only offered on the P/F grading option). If a student is ready to complete a graduate degree and grades of "I", "X", "NG" or "NR" are present on the transcript but off the Plan of Study, the department should investigate why these grades have not been remedied. In many cases these grades reflect unresolved problems or errors that can and should be remedied. However, as long as the student has a GPA of 3.0 or better both on the Plan of Study and overall, these grades can remain on the transcript and not interfere with degree completion.

Grading System Requirements

All courses taken at Virginia Tech that are included on the Plan of Study, i.e., courses that satisfy degree requirements, must be taken for a letter grade (A/F) except for those courses offered on a pass/fail (P/F) basis only (for example, Independent Study courses and most seminars are only offered P/F). Courses on the Plan of Study with grades below "C-" must be repeated. Courses on the Plan of Study, once taken, cannot be removed from the Plan of Study. Graduate students are permitted to take additional courses on a pass/fail basis only if those courses are not on their Plan of Study, are outside the department, and are approved by the student's advisor. Such courses may not be used to satisfy minimum degree requirements. Under the graduate P/F grading option, a "P" is granted for earning a "C-" or better in a course. Once credit is received for a course taken P/F, the course may not be repeated under the A/F grading system.

Repeating Courses

Courses originally taken on the P/F option, in which a grade of "F" is earned, may only be repeated on a P/F basis. Courses may not be repeated if a "P" grade is earned, or without permission of the Graduate School if a grade of "C-" or better is earned. When a course is repeated the grade for the earlier enrollment will be a Repeat Graduate ("RG", defined as a grade of "C-" or lower; "RP", defined as a grade of "C" or

higher, when the course was first taken) which will not calculate into the GPA. Only the grade earned for the final enrollment in the course will receive a letter grade and be calculated in the GPA. If a student wishes to repeat a course in which the first grade earned was a C- or higher, permission for a policy exception must be obtained from the Dean's office prior to taking the course a second time.

Auditing

An audit requires approval of the instructor. Auditing of laboratory work is not permitted. Registration for Audit may not be changed to credit, or vice versa, after the last day to add classes without an exception to policy by the instructor, the student's major advisor, and the Dean of the Graduate School. If the student or the instructor expects evaluation of coursework, then the student must enroll either as a P/F option or for a letter grade. If a faculty member wishes to require the participation of auditing students in selected activities, then that should be stated in the syllabus or communicated to the student. Students are assessed the same rate of tuition and fees for audited courses as for courses taken for credit. Audited courses do not count toward full-time enrollment.

Graduate Credit

Students must have a recognized status with the Graduate School (i.e., have been admitted to graduate studies) and be officially enrolled in a course to earn graduate credit in that course. Graduate courses at Virginia Tech are numbered 5000 or higher. As of Fall 2009 there are no 4000-graduate approved courses (see information about the limited use of undergraduate courses on Plans of Study). Instructors should not allow students to attend if they are not enrolled in a course (i.e., are not on the official Class List, which can be viewed on HokieSpa in Faculty Access, by the end of the Add Period for the semester). Students should resolve all enrollment problems before the end of the Add Period to be able to obtain credit for a course.

On-line Courses/Independent Study in Absentia/Continuing Education

On-line courses offered for graduate credit from accredited universities may be considered for transfer credit (see section on transfer credit limitations in Plan of Study). Independent study (5974) or Graduate Research credits (5994 or 7994) completed while the student is residing at a distance from the instructor's Virginia Tech location must have regular faculty consultation by means such as email or regular telephone calls. No credit toward graduate degrees may be obtained by correspondence study or from continuing education courses.

Academic Progress

GPA Requirements

Students must obtain a 3.00 GPA, both overall and for courses on the Plan of Study. All courses on the approved plan, including supporting courses must be completed with a grade of "C-" or better (see Graduate Degree and Certificate Requirements section below).

Probation due to Unsatisfactory Grades

Students whose cumulative GPA falls below a "B" (3.00 GPA) will be placed on probation by the Graduate School. Enrollment for one semester of probation normally is permitted to remedy an unsatisfactory GPA. If the student does not achieve a 3.0 GPA within one semester after being placed on probation, the Graduate School will consult with the department about dismissal of the student from Graduate School. A department can appeal to the Graduate School for additional time for the

student to achieve a 3.0 GPA, providing the student is making reasonable progress in raising the GPA. If an appeal is made to the Graduate School for additional time it should come from the departmental Graduate Program Director or the Department Head. If extra time is granted, the student should be informed in writing of the amount of additional time allowed for achieving a 3.0 GPA. If the department does not support a time extension, the student will be dismissed from the Graduate School.

Satisfactory Progress toward a Graduate Degree

All graduate students are required to have an Annual Review of Progress at least once a year by their Advisory Committees. Students who do not yet have a Plan of Study and an Advisory Committee should be reviewed by the Graduate Program Director or a departmental Graduate Committee. If a student fails to make satisfactory progress toward degree requirements (coursework, grades, research, projects, examinations, and other requirements), permission may be denied to continue in the degree program. This decision may be reached by the student's Advisory Committee, a graduate program Evaluation Committee in the department and the Graduate Program Director, or the Department Head, and recommended to the Graduate School. The Graduate School will dismiss the student for unsatisfactory progress following the recommendation by the department. The departmental recommendation should include documentation of at least one review indicating unsatisfactory progress, communication to the student about what was needed to reestablish satisfactory progress, and evidence that the student's progress continued to be unsatisfactory (second review).

Enrollment Limits and Requirements

Full Time Enrollment

Full-time enrollment for graduate students, for purposes of tuition and fees, consists of a minimum of 9 credit hours during academic year semesters. However, the Commonwealth of Virginia does not count students as full time unless they are enrolled for at least 12 credits, and in most academic contexts, 12 credits is considered full time. The maximum number of credit hours is 18 during academic year semesters. Overloads (19 credit hours or more per semester, or more than 6 per summer session) require permission from a graduate dean.

Graduate Student Employment/Assistantships

Graduate Assistants (GAs, GTAs, and GRAs) must enroll for at least 12 credit hours per semester to be eligible for their assistantship. Students on full assistantship are expected to work an average of 20 work hours per week for the assistantship and are considered to be 50% employed. Graduate students on assistantship can enroll for up to 18 credit hours of course work in academic year semesters and up to 6 credit hours during each summer session.

Virginia Tech Employees

Tuition Waivers or Reimbursement: Full-time salaried employees, who have been admitted to the Graduate School (see the section below on Eligibility of Faculty/Staff for Graduate Degrees), and with the approval of their department, may have waived or reimbursed twelve (12) credit hours per calendar year (Fall through Summer II), not to exceed six (6) credits in a Fall, Spring, Summer I, or Summer II term. Part-time salaried employees are eligible for up to 6 credit hours of tuition waiver per academic year. The maximum number of credit hours will include tuition waiver, tuition reimbursement, or a combination of both. For more information, refer to the Human Resources'

Fellowship and Scholarship Recipients

Fellowship and scholarship recipients are required to take at least 12 credit hours each semester in which they are receiving a stipend. These credit hours must represent work toward satisfying minimum degree requirements. Audited courses do not qualify in satisfying this minimum.

Graduate Assistantships

Types of Assistantships

There are three types of graduate assistantships: Graduate Assistant (GA): GAs provide academic and program support to faculty or departments. GA responsibilities may be administrative in nature and consist of duties unrelated directly to teaching or research (such as academic advising, program planning, advising student groups, and assisting with the administration of student services offices). GA responsibilities also may be academic in nature and include grading examinations, problem sets, and/or lab assignments, setting up displays for lectures or laboratory sections, and preparing or maintaining equipment used in laboratory sections. Graduate Teaching Assistant (GTA): GTAs assist faculty in the department in the teaching mission, with assignments including laboratory teaching, grading of examinations, problem sets and/or lab assignments, setting up displays for lectures and laboratory sections, and preparing or maintaining equipment used in laboratory sections. GTAs must have 18 credit hours of graduate-level course work in their teaching discipline to be assigned full responsibility for teaching an undergraduate course. GTAs lacking this training may be assigned to work under the supervision of a faculty member who will be the instructor of record for the course. Graduate students may assist faculty in teaching graduate courses but may not be the instructor of record for the course. GTAs are required to attend and be enrolled in the GTA Workshop (GRAD 5004, 1 cr., P/F) in the first fall semester of their teaching appointment at Virginia Tech. Other students who hope to qualify for a GTA appointment in the future should take the workshop in their first semester at Virginia Tech. The workshop consists of Phase I (two half days, Monday and Tuesday of the week before classes start in August) a wide variety of Phase II sessions during fall semester. Graduate Research Assistant (GRA): GRAs conduct research under the direction of a faculty member, who is typically a principal investigator on an external grant or contract that funds the GRA and determines the nature of research work required for the assistantship. The research work required for the GRA is determined by the funding source and is typically beyond research done for academic credit toward the student's degree.

Academic Eligibility to Hold a Graduate Assistantship

Assistantships may be offered to degree seeking graduate students admitted to Regular (GPA of 3.0 or greater) or Provisional (GPA of 2.75-2.99) status. To continue to be eligible for an assistantship a student must maintain a GPA of 3.0 or higher and be making satisfactory progress toward attainment of a graduate degree. The academic department and the Graduate School may allow a student to continue on an assistantship for one semester of probationary status to remedy grade deficiencies. Students on assistantships must be enrolled for a minimum of 12 credit hours per academic year semester. Audited courses do not qualify in satisfying this minimum. Graduate students holding assistantships during the academic year and/or in the summer are not required to enroll during summer sessions, except if they are taking a preliminary or final examination.

Additional Employment for Students Holding a Graduate Assistantship

Unless specified otherwise in the assistantship agreement contract, graduate students on full assistantships are not prohibited from seeking additional employment. Students should consult with their academic advisor and/or assistantship supervisor as applicable regarding the fulfillment of their assistantship and graduate study responsibilities. Students must notify the Graduate School about any additional employment agreement, including the period of employment, name and contact of employer, and job title or short description of duties <https://secure.graduateschool.vt.edu/aert/logon.htm>.

Graduate Degree and Certificate Requirements

General Degree Requirements for Graduate Students

For a graduate student, the university degree requirements are those identified in the Graduate Catalog (Policies and Procedures) effective for the academic year in which the student files the Plan of Study. If the requirements will change in the coming academic year (cases where the governance system has set new policy to be effective at the beginning of the next academic year), the graduate student may choose, but is not required, to abide by the "new" requirements. For graduate students not enrolled for more than one calendar year, requirements will be reviewed on a case-by-case basis at the time of Readmission.

Plan of Study

Submission and Approval Submission and Approval. All graduate students must submit a Plan of Study that meets at least the minimum Graduate School requirements for the designated degree. The Plan of Study must be approved by the student's Advisor and Advisory Committee, the Graduate Program Director or Department Head, and the Graduate School. All courses on the Plan of Study, including supporting courses, must be taken on a letter grade (A/F) basis except for those courses approved to be graded on a pass-fail (P/F) basis only. Audit courses cannot be included on the Plan of Study. After approval by the student's Advisory Committee and the Graduate Program Director or Department Head, the Plan of Study should be entered and sent electronically to the Graduate School for approval, according to the following schedule. Master's: The Plan of Study is due by the end of the second academic semester for all Master's degree students (based on full time enrollment of 12 credits per semester). For the Master of Architecture or Master of Urban and Regional Planning degrees, the Plan of Study is due before 30 credit hours are completed. For Bachelors/Masters students, the Plan of Study is due by the end of the first full semester of graduate study. Ph.D.: The Plan of Study is due by the end of the third academic semester for all doctoral students (based on full time enrollment). Ed.D.: The Plan of Study is due no later than 30 days after the successful completion of the required qualifying examination. The qualifying exam is an Ed.D. requirement, not a Graduate School requirement. Transfer Courses on the Plan of Study Transfer Courses on the Plan of Study. No more than 50% of the graded credit hours needed to satisfy the requirements for a Virginia Tech graduate degree may be transferred in from a regionally accredited university. All such credits must have earned grades of "B" or better, have been earned while in good standing in graduate status, and must have been graduate courses (numbered 5000 or higher) at the institution where the student took the courses. Grades of "S" or "P" are not acceptable for transfer credit. All transfer courses must be acceptable to the student's Advisory Committee and the Graduate Program Director or Department Head. For transfer course work more

than five years old, a Justification of 'Old' Course Work form must be filed with the Plan of Study (see below). Credits from other universities are transferred to a Virginia Tech graduate degree at the time the Plan of Study that includes those courses is approved by the Graduate School. Transferred courses count only as credit hours and are not included in the calculation of the Virginia Tech GPA. Official transcripts are required before transfer course work can be approved for the Plan of Study. Research, Project and Report, Practicum or Internship credit hours may not be transferred in from another university to meet Virginia Tech graduate degree requirements (i.e., they cannot be included on the Plan of Study). Credits taken while in undergraduate status or for an undergraduate degree cannot be used as transfer credit for a graduate degree.

Justification of 'Old' Course Work

Justification of 'Old' Course Work. Academic work, including transfer credit more than five years old at the time the Plan of Study is submitted, requires Justification for inclusion on the plan. The Justification form requires an Advisory Committee explanation of how the committee will insure that the student will update their knowledge for out-of-date courses. The Course Justification Request form is at http://graduateschool.vt.edu/content/dam/graduateschool_vt_edu/GAAPforms/Course_Justification_Request.pdf and some procedural guidelines are at http://graduateschool.vt.edu/academics/graduate-catalog-policies-procedures/justification_of_old_coursework.html Justifications remain valid throughout the degree unless the student is out of enrollment for a period exceeding one calendar year. Justification of "old" course work and review of the Plan of Study occurs at the time of re-admission.

Supporting Courses

Supporting Courses. Supporting courses are those the student's Advisory Committee considers necessary to provide missing background for taking the key courses required for the student's degree program. Courses numbered lower than 4000 can only be used on the Plan of Study as Supporting Courses. All courses listed on the Plan of Study, including Supporting Courses are requirements for the degree and must be completed with a grade of "C" or better. However, supporting courses do not count toward the minimum number of credit hours required for the degree.

Plan of Study Changes

Plan of Study Changes. A Plan of Study Change Form http://graduateschool.vt.edu/content/dam/graduateschool_vt_edu/GAAPforms/Plan_of_Study_Change.pdf is necessary whenever changes are made to the course work on the Plan of Study. Changes to the Plan of Study must be approved by the student's Advisory Committee, the Department Head or Graduate Program Director and the Graduate School. Once a course on the Plan of Study has been taken for a grade, it must remain on the Plan of Study.

Change of Thesis Option

Change of Thesis Option. A master's degree candidate is allowed to change from the thesis to the non-thesis option (or vice versa) only once. These changes require approval of the Department Head/Graduate Program Director and the Chair of the student's Advisory Committee. Use this form: http://graduateschool.vt.edu/content/dam/graduateschool_vt_edu/GAAPforms/Thesis_Option_Change_Request.pdf. Such changes often require changes in the coursework and Plan of Study.

Grades on Plan of Study Courses

Grades on Plan of Study Courses. All graded courses on the Plan of Study must be taken for a letter grade (A/F) except for those courses offered on a pass/fail (P/F) basis only (for example, Independent Study courses and many seminars are only P/F). Students must maintain a 3.0 GPA or better on the Plan of Study course work. Once a course on the Plan of Study is taken for a grade, it must remain on the Plan of Study.

Repeating Courses on the Plan of Study

Repeating Courses on the Plan of Study. Students are required to repeat any courses on the Plan of Study in which a grade below "C-" has been earned. Courses may not be repeated if a "P" grade is earned or without permission of the Graduate School if a grade of "C-" or better is earned. After a course has been repeated, the grade for the first enrollment will be Repeat Graduate (RG, defined as a "C-" or lower; RP, defined as a grade of "C" or higher when the course was first taken). Only the most recent enrollment in the course will receive a letter grade and be calculated in the GPA.

Graduate Advisory Committees

Committee Functions The student's advisory committee works with the student to design a Plan of Study, approves the Plan of Study, provides advice, conducts required examinations and regularly assesses the student's progress and accomplishments. Advisory committee members are appointed by the Graduate School on recommendation of the Department Head or Graduate Program Director via submission of a Plan of Study listing the proposed committee members. Committee Composition and Size Advisory committees will be composed principally of Virginia Tech-associated Graduate Program faculty members, who have the primary responsibility for the operation and integrity of graduate education programs in their departments, schools, and programs ("academic units"). These individuals are recommended by their academic units to serve as Graduate Program faculty members on the basis of having earned the appropriate terminal degree (or having gained equivalent professional experience), maintaining a record of scholarly productivity, and showing evidence of successful involvement with graduate education within the previous five years. Virginia Tech faculty members who meet the three criteria above can serve as Chairs, Co-Chairs, or Members of graduate student advisory committees. Eligible faculty categories include the Tenured/Tenure-track, Clinical, Extension, Collegiate, Research, and Professor of Practice ranks as defined in the Virginia Tech Faculty Handbook. Virginia Tech faculty members who meet the first two criteria but have not previously had the opportunity to advise or supervise graduate students can, if paired with or mentored by an experienced Virginia Tech faculty member, qualify as Graduate Program faculty and can serve as Chair, Co-Chair, or Member on graduate student advisory committees. Department Heads/Chairs or Graduate Program Directors may nominate faculty members in their academic units for Graduate Program Faculty status by submitting the form at http://graduateschool.vt.edu/content/dam/graduateschool_vt_edu/GAAPforms/graduate-committee-service-approval-form.pdf. A student pursuing a Master's degree must have an advisory committee of at least three faculty members with the appropriate terminal degree (i.e., Master's degree or higher). In some instances, it is appropriate to have fewer (minimum of 1) faculty members serving on the advisory committee when students are pursuing a coursework-only degree (e.g., MBA). Departments offering coursework-only degrees can petition the Commission on Graduate and Professional Studies and Policies for approval to reduce the size of the committee. Doctoral candidates must

have an advisory committee of at least four faculty members with the appropriate terminal doctoral degree or the equivalent in professional experience. The student should also refer to the departmental policies and procedures document for any guidelines for graduate advisory committee service or composition specific to their department or program. In addition to members of the Graduate Program faculty, other individuals can be appointed to serve as Members, or under certain circumstances as Co-Chairs, on graduate student advisory committees. This category includes retired or Emeritus Virginia Tech faculty members, Virginia Tech employees (e.g., Research Scientists, Administrative/Professional Faculty, Instructors, and non-Virginia Tech-employed individuals including Adjunct Faculty, who are qualified by terminal degree/professional experience and scholarly productivity and who, by inclusion, can provide specific expertise to enrich the student's program. Recommendation that such an individual be appointed to serve on a graduate student's advisory committee must be made by the student's home academic unit (using the form identified above) and approved by the Graduate School. Identification of Committee Members Selection of an individual student's advisory committee membership, drawn from the Virginia Tech Graduate Program faculty and, if desired, approved non-Graduate Program faculty individuals, is performed jointly by the student and his/her advisory committee Chair and approved by the Graduate Program Director of the student's home academic unit. Graduate Program faculty members must constitute at least two-thirds of the minimum committee membership (e.g., at least two of the three members for master's degrees and at least three of the four members for doctoral degrees). Once the minimum committee membership total has been satisfied as described, individuals not meeting the criteria of degree/experience credentials, scholarly achievement, and graduate education experience may be added as additional Members of a student's committee if, in the view of the student's home academic unit, that individual can provide specific expertise to enrich the student's program. Approval of these individuals for service is likewise recommended via the form identified above. In selecting members of their advisory committees, students and their committee Chair should take pains to avoid situations that might create conflicts of interest for the student or be impacted by coercive relationships among the committee members or between the student and committee members. It is of paramount importance that all committee members be free to evaluate the student's work based on its academic merit alone. Composition of the student's advisory committee is communicated by the Graduate Program Director to the Graduate School in the form of the student's Plan of Study, on which all committee members are signatories. Additional considerations Faculty members are not permitted to serve as Advisor or committee member for family members (spouse or dependent immediate family member), nor for individuals with whom they have a close personal relationship, such as partner or extended family member, or a close professional relationship such as business associate or supervisor. A faculty member with a significant financial interest may not serve as sole advisor of a dissertation or thesis committee for a student who is funded through a university sponsored project supported by the advisor's company, or for a student who is employed directly by the faculty member's company. The faculty member with the conflict may serve as co-chair or committee member. If another Chair is appointed, that faculty member must be of equal or greater rank, must not be involved with the sponsoring company, and must not be subject to undue influence by the faculty-owner. See Policy 13010 for a complete description of the disclosures and protections required in such instances. Graduate students (including those Virginia Tech employees who are pursuing graduate degrees) may not serve on a graduate Advisory and/or Examining Committee. Post-doctoral scholars or other advanced degree holders who have earned their graduate degrees at Virginia Tech will not be approved for service on advisory committees of students with

whom they overlapped as students. See also Eligibility of Faculty/Staff for Graduate Degrees (https://secure.graduateschool.vt.edu/graduate_catalog/policies.htm?policy=002d14432c654287012c6542e3720084) for a description of steps needed to document the delineation of employment duties from degree-seeking research work. Changes in a Student's Advisory Committee Changes in a student's advisory committee will be granted only on approval of all committee members (new and old) and on recommendation by the Department Head or Graduate Program (http://graduateschool.vt.edu/content/dam/graduateschool_vt_edu/GAAP/forms/Change_of_Committee-Advisor.pdf). In the case that one or more members does not approve the change in the membership of the Advisory Committee, an appeal may be made by either the student or a faculty member to the Department Head. If the Department Head considers the appeal to have merit, he/she may then ask the Graduate School for an exception to all members signing the form. If the Chair of an Advisory Committee leaves the university or retires during the student's degree program, the department should consult with the Dean's Office in the Graduate School to determine the most appropriate continuing committee composition for advising of the student to degree completion.

Scholarly Ethics and Integrity

All graduate students are expected to uphold the Virginia Tech Principles of Community and the Graduate School's Expectations for Graduate Education as well as the scholarly integrity and research ethics standards of their disciplines. Graduate students must complete degree program requirements for learning about 4 required scholarly ethics and integrity topics plus additional topics relevant to the discipline as follows.

Required topics : 1. Plagiarism and other violations of the Graduate Honor Code 2. Proper use of professional conventions in citation of existing research and scholarship, accurate reporting and ownership of findings, and acknowledgement of contributions to the work 3. Ethical standards in teaching, mentoring, and professional activities 4. Available avenues for reporting alleged misconduct Additional topics, as relevant to the discipline : 1. Appropriate lab procedures and maintenance of lab notebooks and other research documentation 2. Fair use of publications, software, and equipment 3. Appropriate research protocols involving human and animal subjects; Institutional Review Board and/or Institutional Animal Care and Use Committee certification 4. Guidelines for maintenance of confidentiality (and, where relevant, anonymity) in research 5. Guidelines for determination of authorship 6. Appropriate grant and contract management, including appropriately asserting personal or program capacities and competencies when applying for grants and contracts 7. Discipline or fieldspecific professional ethics

Credit Hour Requirements for Degrees and Certificates

Master's Degree

Virginia Tech allows for both thesis and non-thesis master's degrees. For each degree type, the student's Plan of Study must meet the semester credit hours requirements shown below. Departments/programs may have additional requirements and an advisory committee may add specific requirements needed for an individual student's academic development. Graded credits must be taken for an A/F grade unless the course is only offered P/F (see Grading System Requirements). See Transfer Credit for policies about the transfer of graduate credits for use on the Plan of Study. See Undergraduates taking Graduate Courses for policies allowing Bachelor/Master's students at Virginia Tech to transfer some courses

from the bachelor's degree to the master's degree (also referred to as double counting courses toward both degrees). Thesis Master's Minimum total credits: 30 credit hours Minimum graded credits: 20 credit hours May include a maximum of 6 credits of Virginia Tech 4000-level undergraduate course work The 6 credits of Virginia Tech 4000-level course work may include Special Study (4984) courses but may not include Undergraduate Independent Study (4974) or Undergraduate Research (4994) courses. All other graded course work must be 5000 level or higher (i.e., graduate course work) The 5000-level course work may include a maximum of 6 credits total in 5974, 5984, and 6984 courses and 3 credits of seminar. Some departments have approval from the Commission on Graduate and Professional Studies and Policies to reduce the minimum number of graded course work credits required for a specific degree program. See departmental degree requirements to determine if a department has approval for such changes in requirements. Minimum research credits: 6 credit hours of Master's Research (5994) taken at Virginia Tech. Non-thesis Master's Minimum total credits: 30 credit hours Minimum graded credits: 24 credit hours May include a maximum of 6 credits of Virginia Tech 4000-level undergraduate course work The 6 credits of Virginia Tech 4000-level course work may include Special Study (4984) courses but may not include Undergraduate Independent Study (4974) or Undergraduate Research (4994) courses. All other graded course work must be 5000 level or higher (i.e., graduate course work) The 5000-level course work may include a maximum of 9 credits total in 5974, 5984, and 6984 courses and 3 credits of seminar. Maximum project and report or research credits: May include a maximum of 6 credits of Project and Report (5904) credits taken at Virginia Tech

Second Master's Degree

Second Master's Degree (both degrees at Virginia Tech). The requirements for a second master's degree (after the first master's has been completed) are the same as for the first master's degree: an additional 30-54 hours, depending on the degree sought. No more than 50% of appropriate graded course work, to meet the requirements for a master's degree, may be common to both degrees. For example, if one master's degree requires 20 credits of graded coursework and the other requires 30 credits of graded coursework, no more than 10 credits (50% of the graded work on the degree with lower graded credit requirements) can be used toward both degrees. No Research or Project and Report credits from the first master's degree can be used for the second master's degree. No credits can be triple-counted. If the first master's degree is from another university, see Transfer Credits.

Simultaneous Degrees

If a student wishes to pursue two graduate degrees in different departments simultaneously, an Application for Simultaneous Degree must be submitted http://graduateschool.vt.edu/content/dam/graduateschool_vt_edu/GAAPforms/simultaneous_degree.pdf . No more than 50% of appropriate graded course work requirements for a master's degree may be common to both degrees. For example, if one master's degree requires 20 credits of graded coursework and the other degree requires 30 credits of graded coursework, no more than 10 credits (50% of the graded work on the degree with lower credit requirements) can be used toward both degrees. No Research or Project and Report credits from one degree may be counted toward the other degree. No credits can be triple-counted.

Education Specialist Degree (Ed. S.)

The Education Specialist Degree (Ed.S.) is a post-master's program

requiring 60 credit hours. The program consists of 30 credit hours (minimum) from Virginia Tech and up to 30 credit hours of transfer credit from the master's degree. At least 21 credit hours must be completed at Virginia Tech after acceptance into the Ed.S. degree program. In this program, candidates are expected to attain a broad and systematic understanding of professional education, a definitive knowledge of a particular field of specialization and the ability to integrate and apply theoretical concepts of education in an actual educational context. This graduate program is designed for the accomplished, experienced practitioner with special professional aspirations beyond the masters, but who generally does not wish to pursue a doctorate. The Ed.S. is designed to meet this need and is offered in several specialty areas.

Doctoral Degrees

Doctor of Philosophy (Ph.D.) Doctoral degrees at Virginia Tech must meet the semester credit hour requirements listed below and include a dissertation that involves original research/scholarship. Departments/programs may have additional requirements and an advisory committee may add specific requirements needed for an individual student's academic development. Graded course work on the Plan of Study must be taken for an A/F grade unless the course is only offered P/F (see Grading System Requirements). Students can apply graded coursework credits taken at Virginia Tech for a master's degree at Virginia Tech to a doctoral plan of study in the same program area if the Advisory Committee considers the courses appropriate for the doctoral degree. No Research and Thesis or Project and Report credits from a master's degree can be used for a doctoral plan of study. See Transfer Credit for policies about the transfer of graduate credits for use on the Plan of Study. Minimum total credits: 90 credit hours Minimum graded credits: 27 credit hours The Plan of Study may include a maximum of 6 credits of Virginia Tech graded 4000-level undergraduate course work. The 6 credits of Virginia Tech 4000 level course work may include Special Study (4984) courses but may not include Undergraduate Independent Study (4974) or Undergraduate Research (4994) courses. All other graded credits must be at the 5000 level or higher (i.e., graduate course work). Some departments have approval from the Commission on Graduate and Professional Studies and Policies to reduce the minimum number of graded course work credits required for a specific degree program. See departmental degree requirements to determine if a department has approval for such changes in requirements. The 5000-level course work may include a maximum 18 credits total in 5974, 5984, and 6984 courses and 4 credits of seminar. Minimum research credits: 30 credit hours of Doctoral Research (7994). Doctor of Education (Ed.D.) The Graduate School course work requirements for the Ed.D. are the same as those listed above for the Ph.D. with the exception that the minimum number of Research and Dissertation 7994 credits is 24. The dissertation for the Ed.D. typically demonstrates the candidate's ability to investigate phenomena in educational institutions or service agencies to increase practitioners' understanding of practical problems and issues.

Residency Requirements for Doctoral Degrees

Doctoral Degrees Virginia Tech offers four doctoral degrees: the Doctor of Philosophy (PhD), the Doctor of Education (EdD), the Doctor of Veterinary Medicine (DVM), and the Doctor of Medicine (MD). The PhD and EdD degrees are offered through the Graduate School, the DVM is offered through the Virginia-Maryland College of Veterinary Medicine, and the MD is offered through the Virginia Tech Carilion School of Medicine. The PhD is a research degree that focuses on "basic research that expands the knowledge base of the field" while the EdD is focused more on "applied research related to professional practice" (Council of Graduate Schools, CGS, 2005). The nature and purpose of

the PhD is described as the following (CGS, 2005): “The Doctor of Philosophy program is designed to prepare a student become a scholar: that is, to discover, integrate, and apply knowledge, as well as to communicate and disseminate it. Such skills may lead to careers in social, governmental, educational, biomedical, business, and industrial organizations as well as in university and college teaching, research and administration. The PhD. Program emphasizes the development of the student’s capacity to make significant original contributions to knowledge in a context of freedom of inquiry and expression. A well-prepared doctoral student will have the ability to understand and critically evaluate the literature of the field and to apply appropriate principles and procedures to the recognition, evaluation, interpretation and understanding of issues and problems at the frontiers of knowledge. The student also will have an appropriate awareness of and commitment to the ethical practices appropriate to the field.” (p. 1) In accordance with the definition of doctoral degrees as involving mastery of intellectual principles, development of original scholarly contributions to the chosen field or fields, and critical evaluation of issues and problems in relevant disciplines, residency is required for all doctoral students at Virginia Tech. Doctoral Residency Guidelines Residency allows students to concentrate focused time on their degree, acquire the necessary “habits, attitudes, skills, and insights” (CGS, 2005) required for contributions to scholarship, and have opportunities to work closely with other scholars including faculty and other graduate students. These scholarly skills, attitudes, and experiences go beyond acquiring knowledge in classes and beyond experience in professional practice. The Graduate School expects all graduate programs to encourage and provide opportunities for immersion of doctoral students in scholarship. Residency goals can be achieved by multiple means, including but not limited to individual and group research training; providing access to resources such as libraries, research equipment, scholarly materials, and laboratories; providing networking opportunities with Virginia Tech and external scholars and graduate students; participation in scholarly seminars presented by scholars from Virginia Tech or elsewhere; assisting with developing applications for external funding of scholarly endeavors; participation at scholarly conferences; and publications or other forms of scholarly dissemination. Residency for doctoral degree programs (PhD, EdD) can be accomplished through one of three mechanisms. Two consecutive semesters of full-time enrollment: Programs will be expected to provide opportunities during those two semesters to cultivate immersion in scholarship and achieve the goals of residency. Students completing residency via full-time enrollment should understand residency goals and plan not only to complete required courses, but also to sustain scholarly engagement and immersion in research, scholarship and professional development. Program-specific alternative residency plan: Academic degree programs may propose alternative methods by which enrolled students will achieve residency goals to be approved by the Graduate School. Program-specific alternatives may be proposed for doctoral degree programs offered outside Blacksburg or on the Blacksburg campus. Individual alternative residency plan: Proposals for alternative residency from individual students can be submitted for approval by the Graduate School. Each academic degree unit should determine the mechanism through which the doctoral students can satisfy the residency requirement. Academic units may utilize any or all of the three options as determined appropriate by the graduate program faculty. For existing degree programs, the enrollment-based requirement will serve as the mechanism unless a specific request is made for a program-specific alternative residency plan. For new degree programs, the mechanism for earning doctoral residency should be included in the proposal submitted for approval through the governance process. Proposals for alternative residency plans (program-specific, individual) should include a description of how the alternative plan will help achieve the purposes and goals of doctoral residency: Please provide strategies

for each of the following goals: Disciplinary depth and breadth Access to a wide variety of classes and academic experiences in the student’s field and in related disciplines Access to library, information technology, and laboratory resources Quality and rigor of the program through involvement with and scrutiny by peers in other disciplines Scholarly immersion Development of the student’s capacity to make significant original contributions to knowledge in a context of freedom of inquiry and expression (e.g., individual and group research training, assisting with developing applications for external funding, participation at scholarly conferences, publications or other forms of scholarly dissemination). Ability to understand and critically evaluate the literature of the field and to apply appropriate principles and procedures to the recognition, evaluation, interpretation and understanding of issues and problems at the frontiers of knowledge. Professional socialization Substantial interaction with a large pool of faculty to obtain scholarly and disciplinary advice, perspective, and guidance Interaction with fellow graduate students on professional issues Provision of a broad range of professional development experiences to guard against over-specialization Access to a wide spectrum of seminars, professional presentations, and contact with leaders in their own discipline as well as others Professional practice Awareness of and commitment to the ethical and regulatory principles and practices appropriate to the field. Program-specific alternative residency proposals should clearly identify the various methods the program will utilize to promote scholarly immersion and achieve the goals of residency as discussed above. The plan should consider the goals of residency and outline the ways these will be achieved, including specific activities and the timeframe as appropriate during which residency will be completed. Program-specific alternative residency plans should be submitted by the academic unit to the Graduate Dean for review and approval. Proposals should be submitted at least one semester before the desired effective date for implementation. Proposals will be reviewed and feedback provided within 30 days of submission. As needed, initial proposals can be revised for final review and approval. In addition, programs can submit revised or updated plans if elements of the degree program change. Individual alternative residency proposals must be submitted by the student and faculty advisor/committee as appropriate to the Graduate School for review and approval. Students should begin planning with their advisors early in their degree programs. Individual alternative residency plans must be submitted to the Graduate School as early as possible or at the latest, concurrent with submission of the Plan of Study. Alternative residency will be approved by the Graduate Dean before approval of the Plan of Study Recording of residency plans: All doctoral students should indicate the mechanisms by which they plan to earn residency on the Plan of Study form. Should a change in residency plan be required, students can seek approval of such change via the Plan of Study Change form accompanied by relevant documentation. Second Doctoral Degree A student who is seeking a second doctoral degree, regardless of whether the first was earned at this university, must earn a minimum of 48 additional semester credits and must satisfy the residency requirements specified for the doctoral degree at Virginia Tech. No credits can be triple-counted.

Graduate Certificates

Graduate certificates can be awarded to individuals who do not desire to work toward a degree as well as to students who are working on graduate degrees. Of the graduate course work (5000-level or higher courses) for the certificate, at least 2/3 must be graded course work taken on the A/F grading option. Certificates must include a minimum of 9 credit hours of Virginia Tech graduate course work credits. No transfer credits can be applied to graduate certificates. No more than 50% of the credits for a particular graduate certificate can be double-counted toward

another graduate certificate, and credits for a particular course cannot be counted toward more than two certificates. All credits for a graduate certificate can duplicate credits on a degree plan of study. All grades for certificate courses must be "C" or higher and the overall certificate GPA must be 3.0 or higher. The specific requirements for each certificate can be found on the Graduate School Certificate

Page: https://secure.graduateschool.vt.edu/graduate_catalog/certificates.htm. Certificate candidates must be admitted to the Graduate School and formally accepted to the certificate

program: <http://graduateschool.vt.edu/admissions/how-to-apply.html>

Upon successful completion of certificate requirements, an Application For Certificate Conferral

http://graduateschool.vt.edu/content/dam/graduateschool_vt_edu/GAAP_forms/Application_for_Degree_or_Certificate.pdf must be signed by the department and submitted by the Application for Degree deadline in the term in which the certificate will be awarded. Meeting this deadline is necessary for the student's name to appear in the commencement bulletin. http://graduateschool.vt.edu/academics/commencement_deadlines.

Examinations

All graduate examinations are open to the faculty and faculty members are encouraged to attend and participate in such meetings. The student must be registered during the semester in which any examination required by Graduate School Policies is taken.

Scheduling Examinations

Scheduling Examinations: Examinations required by Graduate Policies and Procedures (Preliminary and Final Examinations), are scheduled through the Graduate School. <https://ess.graduateschool.vt.edu> Requests to schedule examinations must include the time, date, building and room number, title of dissertation or thesis, and the names and signatures of the Examining Committee. These requests are due in the Graduate School at least two weeks before the examination date requested. Notification of the approval of the examination scheduling will be sent electronically to the student and all members of the Examining Committee. The examination should not be conducted if the Advisor has not received notification that the examination has been scheduled. The examination result should be entered in the Electronic Signature System within 2 days after the examination, with each committee member signifying whether the exam performance was Satisfactory or Unsatisfactory. Preliminary examinations and non-thesis final examinations can be scheduled through the last day of exams for the term. Final examinations for master's thesis and doctoral students must be scheduled early enough in the term to meet the final ETD submission date. Before filing the request for scheduling an examination, the student's record should be reviewed by the department to make sure that the Plan of Study has been filed and approved and that there are no problems. The Graduate Program Director's signature on the form is the departmental verification that the Plan of Study has been examined and that it is appropriate for the student to schedule the examination. For Preliminary Examinations, which commonly are comprehensive examinations of the doctoral coursework, typically students complete the formal coursework on the Plan of Study prior to taking the exam. If a student has coursework remaining to be taken, the department should determine whether or not it is appropriate for the student to take the examination before all the graded coursework on the Plan of Study is completed. Students may take the Preliminary Examination despite having some grade problems on the Plan of Study (e.g., Incompletes, grades <C- that require retaking a course) but the student's Advisory Committee should address whether this will put the student at a disadvantage on the exam. If the decision is to schedule the exam in a

case like this, a note addressing the committee's decision to move forward with the exam should accompany the exam request. By the end of the degree, all grades on the Plan of Study must be a C- or higher and the Plan of Study and overall GPA must be 3.0 or higher. For scheduling of the Final Examination, Thesis Master's and Ph.D. students must have the thesis/dissertation ready for defense (as judged by Advisory Committee members having read the document and signed the examination scheduling request) and the student must be able to complete all other degree requirements within the semester when the examination is held: all coursework on the Plan of Study will need to be completed with grades of C- or higher and both the Plan of Study GPA and the overall GPA must be a 3.0 or higher by the end of the semester. Because some of the problem situations with deficient grades or credits require retaking courses or adding credits, the Plan of Study should be examined at the beginning of the semester in which a student plans to take the Final Examination. For Non-thesis Master's students, scheduling of the Final Examination requires that the student will be able to complete any Project and Report or Independent Study requirements, complete all coursework on the Plan of Study with grades of C- or higher and attain a Plan of Study and overall GPA of 3.0 or higher by the end of the semester. Students wishing to schedule the Final Examination, who have not been enrolled at Virginia Tech for more than a year, need to file for Readmission and allow enough time for any problems to be resolved so they can be Readmitted prior to the 2 week period needed for Exam scheduling. The minimum enrollment is 3 cr. For enrollment requirements when taking a Final Examination, see below. Required examinations are administered during regular academic semesters or sessions, i.e., between the first day of classes for a given semester or session and ending with the last official day for examinations. Permission to schedule an examination in the time between sessions may be granted if an explanation of special circumstances requiring that scheduling is made to the Dean's office of the Graduate School by the student's Advisor. Scheduling of examinations between semesters/terms does not alter ETD submission or approval deadlines.

Examining Committees

At least four scholars eligible to serve are required to participate on every doctoral Advisory Committee, and at least three are required for every master's Advisory Committee. All members of a student's Advisory Committee are required to participate in that student's doctoral (preliminary and final) or master's (final) examinations. If one of the Advisory Committee members cannot participate, the committee member should recommend to the Chair of the Advisory Committee, when possible, the name of a scholar eligible for advisory committee membership to serve as a proxy on the Examining Committee. After consultation with the student, the Chair of the Advisory Committee makes such a proxy appointment in writing. Regardless of the size of the size of the Committee, only one official proxy will be approved. Those conducting the examination must log in to the Electronic Signature System and enter their decision on the exam result within 2 days after the exam. The proxy must communicate with the committee member for whom he or she is serving as a proxy regarding the exam result decision and the original committee member must log in to the Electronic Signature System and enter the decision. All committee members must also signify approval or disapproval of the thesis/dissertation in the Electronic Signature System. This signifies that the thesis or dissertation is in final form and ready for ETD submission to the Graduate School.

Successful Completion of Required Examinations

To pass any of the required examinations, a graduate student is allowed at most one Unsatisfactory vote. If a student fails an examination, one full semester (a minimum of 15 weeks) must elapse before the second

examination is scheduled. Not more than two opportunities to pass any one examination are allowed. A student failing any of the examinations required by Graduate Policies two times will be dismissed from graduate studies by the Graduate School.

Final Examination (Master's)

An oral and/or written final examination or evaluation is required in all master's programs (see departmental policy for specific format). For some non-thesis master's programs, final exams are structured in special ways, including evaluation of a project as the final examination. For non-thesis, coursework-only master's degree programs, the committee will conduct a final evaluation of the student's record to confirm degree completion. All master's final examinations and non-thesis, coursework only evaluations are scheduled through the Electronic Scheduling System. For more information about master's final examinations, consult the departmental policies and procedures document.

Qualifying Examination (Doctoral)

Certain departments require doctoral students to take a qualifying examination (see departmental policies). The results typically are used to evaluate subject mastery, to determine deficiencies, and to determine whether the student should continue into dissertation research. The results of qualifying examinations are made part of the student's departmental record. Qualifying examinations are not scheduled through the Graduate School.

Preliminary Examination (Doctoral)

The Preliminary Examination is a requirement for all doctoral students. This examination must be taken at least 6 months before the Final Examination. The Preliminary Examination may be oral or written, or both. Schedule the exam at this site: <https://ess.graduateschool.vt.edu>. The examination date requested should coincide with the date when the decision about the student's performance is made. If the Preliminary Examination consists of a written section followed by an oral examination, the examination date requested should be the date of the oral. The results should be reported to the Graduate School within 1-2 days of the decision about the examination. If an Advisory Committee member cannot participate, the committee member should recommend to the Chair of the Advisory Committee, when possible, the name of a scholar eligible for advisory committee membership to serve as a proxy during the examination. After consultation with the student, the Chair of the Advisory Committee makes such a proxy appointment in writing. Regardless of the size of the size of the Committee, only one official proxy will be approved. Individual departments may choose to administer the Preliminary Examination as a written departmental examination for a group of doctoral students. In this case the examination is typically administered by a committee with all members certifying the results to the department. After the results are certified to the department, the members of each student's Advisory Committee, including any proxies, must record approval/disapproval in the Electronic Signature System.

Final Examination (Doctoral)

Final Examination (Doctoral) All doctoral candidates must take a final oral and/or written examination, which is at minimum a defense of the dissertation. See Advisory Committee Approval of Thesis or Dissertation for a full explanation. This examination must be scheduled no earlier than six months after successful completion of the preliminary examination. <https://ess.graduateschool.vt.edu> To be eligible for hooding at Commencement, the Final Examination must be completed and the

Electronic Thesis/Dissertation (ETD) must be approved by the Graduate School by the published deadline for the semester: http://graduateschool.vt.edu/academics/commencement_deadlines

Enrollment and Examinations

Enrollment and Examinations The minimum enrollment for students working on writing their thesis/dissertation (including consulting with their advisor and/or committee during a semester or summer session) is 3 credit hours. Graduate students must be enrolled for the minimum number of credits in the semester or summer session in which they take an exam and in the semester in which they complete a degree: 3 credit hours during a semester or summer session 1 credit hour for students who qualify for Start of Semester Defense Exception (SSDE, see below) in the semester of their final exam Qualifying for Start of Semester Defense Exception Start of Semester Defense Exception (SSDE) is a special enrollment category for students who have fulfilled all requirements, including advisory committee review and agreement that the thesis or dissertation is ready for defense, and are registering only to take the final oral examination. To qualify for start of semester defense exception, a student must have: completed all requirements (including passing grades on all courses on the plan of study), except for the final exam and submitted the final copy of the thesis/dissertation to the advisory committee within the first three weeks of the semester and at least two weeks before the defense and received permission from the advisory committee, who have read the document and consider it ready for defense (to the extent that the student can make corrections and submit the ETD within two weeks of the defense) within the first three weeks of the semester and been enrolled in at least three credit hours the preceding semester and submitted the SSDE form to the Graduate School by the Friday of the third week of classes or no later than three weeks prior to the defense, whichever date comes first Scheduling a Final Exam within the Start of Semester Defense Exception Timeline To defend under SSDE, a student must schedule and attend the defense according to the following timeline: Within the first three weeks of the semester: Submit SSDE form to the Graduate School Wait for the Graduate School to enroll student in 1 cr (students cannot enroll themselves) Submit Application for Degree in HokieSPA Submit Request for Final Examination (at least two weeks prior to the exam date) in the Electronic Signature System Within the first five weeks of the semester:

International students who qualify for SSDE must defend (complete final exam) to maintain immigration status. Understanding Potential Implications of Start of Semester Defense Exception If a student registers for SSDE, his/her enrollment status will be less than full time, which may affect the following: financial aid or loan deferments employment opportunities (not eligible for assistantships or fellowships) visa status (for international students) Students should consult with the Graduate School and/or Office of Scholarships and Financial Aid to understand the consequences and additional requirements that may result from enrolling under start of semester defense exception.

Thesis and Dissertation

Master's degrees

Master's degrees may be thesis or non-thesis and this is specified on the Plan of Study at the time the plan is submitted. For departments where the non-thesis option is available, a master's degree candidate is allowed to change from the thesis to the non-thesis option (or vice versa) only once. A change between thesis and non-thesis requires the filing of a Thesis Option Change form http://graduateschool.vt.edu/content/dam/graduateschool_vt_edu/GAAPf

Doctoral degrees

Doctoral degrees (Ph.D. and Ed.D.) require a dissertation that involves original research.

Independent Effort

Two or more students may work on the same total problem; however, each student must prepare an independent thesis or dissertation on that student's part of the problem. The individual contributions of each student involved in the same problem should be explained in each thesis or dissertation.

Dissertation Format

Dissertations may be prepared in the traditional multi-chapter format or in manuscript format (minimum of two journal articles, plus front and back matter as indicated in the guidelines).

<http://etd.lib.vt.edu/etdformats.html>

Proprietary or Classified Theses and Dissertations

In certain instances a portion of students' thesis or dissertation research might involve proprietary, controlled, or classified information. Although some results might need to be summarized for the sponsor in a separate embargoed document, a completely embargoed thesis or dissertation conflicts with scholarly values of peer review and promotion of knowledge and should be avoided. All theses and dissertations produced to meet Virginia Tech degree requirements should be subject to an open defense and open publication (including ETD submission), and capable of standing as academically-complete works. Since any proprietary or governmental restrictions should be known at the outset, students are expected to seek a pre-research review of their thesis or dissertation plans with the sponsor whenever there is a possibility that certain findings might be subject to embargo. In coordination with the Chair of their Advisory Committees, students should communicate to the Graduate School as soon as possible any anticipated restrictions on their research. Similarly, a pre-publication review should be conducted with the sponsor as early as is prudent to identify any restrictions on publication, including acceptable separation of restricted findings into an embargoed document. Any publication restrictions should be communicated to the Graduate School as soon as they are known or predicted.

Advisory Committee Approval of the Thesis or Dissertation

All members of a student's Advisory Committee are required to participate in that student's final examination. Depending upon the technological resources available, committee members may participate from a remote location. If an Advisory Committee member cannot participate, the committee member should recommend to the Chair of the Advisory Committee, when possible, the name of a scholar eligible for advisory committee membership to serve as a proxy during the examination. After consultation with the student, the Chair makes such a proxy appointment in writing. Regardless of the size of the advisory committee, only one official proxy will be approved. Those conducting the examination must log in to the Electronic Signature System and enter in their decision on the exam result. The proxy must communicate with the committee member for whom he or she is serving as a proxy regarding the exam result decision, and the original committee member must log in to the Electronic Signature System to enter the decision on behalf of the proxy. All committee members must also signify approval or disapproval of the thesis/dissertation in the Electronic Signature

System. This signifies that the thesis or dissertation is in final form and ready for ETD submission to the Graduate School. If a committee member does not approve the thesis/dissertation, that non-approval will be designated on the ETD. A successful candidate is allowed, at most, one negative vote, regardless of the size of the Advisory Committee.

Electronic Thesis and Dissertation (ETD)

Theses and dissertations are submitted electronically. For instructions, see <https://guides.lib.vt.edu/c.php?g=547528&p=3756956>.

Deadline for ETD Submission

The final version of the thesis or dissertation approved by the student's Advisory Committee must be submitted electronically as an ETD to the Graduate School no later than two weeks after successful completion of the final examination. The ETD Approval Form, indicating Advisory Committee approval of the document must be returned to the Graduate School when the ETD is submitted. If the process of ETD revisions leading to Graduate School approval of the ETD extends beyond the posted deadlines for a semester, the student will be enrolled for 1 credit of SSDE in the later semester when degree completion occurs. http://graduateschool.vt.edu/academics/commencement_deadlines

Degree Completion and Graduate School Approval of the ETD

Degree Completion Graduate degrees are completed after the approval of the ETD by the Graduate School and the completion of all other requirements for the degree.

Copyrighting and Microform

The Graduate School does not require students to register their copyright. ProQuest (previously University Microfilms), digitizes abstracts in their book Dissertation Abstracts and also digitizes the dissertations <http://il.proquest.com/brand/umi.shtml> If a master's student wishes to register the copyright, they must apply directly through the Library of Congress Copyright Registration Office. More information concerning the requirements and cost of copyright registration can be found at <http://copyright.gov/eco/>

Intellectual Property

A University Intellectual Property Policy was adopted in 1986 by the university's Board of Visitors. The policy applies to copyrightable material, patentable inventions, and other creations conceived by any faculty member, staff member, or student employee when substantial university resources, such as money or equipment, are used in connection with the conception and/or development of the creation. All such creations are the property of the university and subject to any applicable agreements with funding agencies. If a student employee has conceived a creation, which may belong to the university pursuant to the Intellectual Property Policy, it is his or her responsibility to report promptly the creation to the university. All creations must be reported to the Office of the Vice President for Research. Creations must be reported before publication of the item, or before publication of information relative thereto or before disclosure to an outside firm or agency. Under the existing policy, net income to the university in the form of royalties (etc.) from the creation may be shared equally with the creator(s). Copies of the Intellectual Property Policy and assistance in reporting creations may be obtained from the Office of the Vice President for Research <http://www.research.vt.edu/> or <http://www.vtip.org/>

Procedures for Graduation

Students anticipating degree completion or certificate award must file an Application for Degree (AFD) form http://graduateschool.vt.edu/content/dam/graduateschool_vt_edu/GAAPforms/Application_for_Degree_or_Certificate.pdf or an Application For Certificate Conferral http://graduateschool.vt.edu/content/dam/graduateschool_vt_edu/GAAPforms/Application_for_Degree_or_Certificate.pdf to obtain a diploma or certificate and to have their names appear in the Commencement Bulletin. Submit two forms if receiving both a degree and a certificate. The AFD should be submitted electronically through Hokie SPA. Schedules for those wishing to complete their degrees in time to attend Commencement are posted at http://graduateschool.vt.edu/academics/commencement_deadlines

Graduation Clearance Procedures

Summary of Procedures Summary of Procedures for a candidate for the master's or doctorate degree: 1. Students must be enrolled at Virginia Tech in the term in which the degree is awarded. 2. Filing of Application for Degree, payment of fee. This form makes an individual degree completion checklist available to the student on Hokie SPA. It must be submitted prior to the last day of classes of the term in which the student intends to graduate. 3. Submission of the Request to Schedule Final Examination, two weeks before the proposed examination date for students who have been enrolled during the last year. For those who have been out of residence for more than a year, and require Readmission, the Readmission process should be completed before requesting the Final Examination. 4. Taking Final Examination. 5. Submitting the final version of the thesis or dissertation, approved by the student's Advisory Committee through the Electronic Signature System, as an Electronic Dissertation or Thesis (ETD) within two weeks after the defense. 6. Submitting any applicable supporting documentation for the ETD (e.g., copyright permission letters to reproduce items from other publications, Institutional Research Board approval or exemption notices (if appropriate), UMI form, Survey of Earned Doctorates). 7. Payment of the archiving fee which is required of students at the time the ETD is submitted. 8. Degree Completion requires ETD approval by the Graduate School and completion of all other requirements for the degree.

Commencement Participation

Master's students who have completed their degree requirements, and those nearing completion, can participate in Commencement. However, diplomas are not issued until all degree requirements are met. Summer graduates may attend either fall or spring commencement but must confirm their attendance through Hokie SPA. Doctoral candidates, to be eligible to participate in the doctoral hooding ceremony, must have completed all degree requirements including ETD approval by the Graduate School by the deadlines published each semester on the Graduate School website: http://graduateschool.vt.edu/academics/commencement_deadlines

Academic Regalia

Information on master's and doctor's regalia is available from the University Bookstore, Clothing and Gifts department, 540/231-5991 <http://www.bookstore.vt.edu>

Degree Conferring Dates

In addition to the traditional twice-a-year commencement, two additional

"Degree-Conferring Dates" have been established. These dates appear on the diploma for qualified graduates. These additional degree-conferring dates fall on the last day of final examinations of First Summer Term and Second Summer Term. No commencement ceremonies are conducted during the summer. Students who complete degree requirements during summer may attend the next commencement; students must confirm commencement attendance via Hokie SPA. All degrees conferred between commencements are listed in the next commencement program. Diplomas will be mailed to graduates by first class mail.

Appeals

Graduate Student Appeals

[See additional information in Expectations for Graduate Education: Complaints and Appeals, <http://graduateschool.vt.edu/academics/expectations/expectations-for-graduate-education-overview/complaints-and-appeals.html>] Graduate education is a complex activity involving a high order of student-faculty relationship. It follows that the evaluation of the graduate student's progress is, and must be, dependent in large part on the judgment of the student's Advisor and augmented by the collective judgment of the members of the Advisory Committee. The university, through the Graduate School, defines minimal entrance standards and general rules governing eligibility for continuation in graduate programs. However, the crucial agency in student evaluation is the student's Advisor and other Advisory Committee members. It is important that each graduate student be fully informed, not only of the Graduate School Policies and Procedures, but of any additional departmental program requirements beyond those of the Graduate School. The Graduate School website provides a link to departmental policy requirements at https://secure.graduateschool.vt.edu/graduate_catalog/programs.htm. The department should inform graduate students of their degree requirements at the time of matriculation. It is assumed that most problems involving graduate education will be discussed informally and reconciled at the departmental level. Indeed, most discussions of this kind will commonly occur among the student, the Chair of the student's Advisory Committee, and the other members of the Advisory Committee. However, from time to time serious questions may arise that place the student's status in jeopardy. On these occasions, it is important that the university provide full opportunity for the student's grievance to be reviewed in a judicious manner.

The Departmental Appeal

When a graduate student believes that any work has been improperly evaluated, or believes that there has been unfair treatment, it is expected that the student will take up the questions directly with the faculty member involved. This may be the student's Advisor, other faculty members, or an instructor responsible for a course. If, after earnest inquiry, the matter remains unreconciled, the graduate student will be expected to appeal the question to the Department Head (the Graduate Program Director also may be involved in this level of appeal). If the Department Head is a party to the grievance, the Dean of the academic college will assume this responsibility. The Department Head, in consultation with the college Dean, shall take all reasonable and proper actions to resolve the question at the departmental level. The student shall be informed in writing of the results no later than one month after the appeal to the Department Head. In some matters, the Faculty Handbook provides additional relevant information, for example, "the assigning of grades is the responsibility of the individual instructor in every case. The basis on which grades are assigned rests on his/her

judgment alone....").

The University Appeals Procedure

Should the aggrieved student believe that the student's rights were abridged at the departmental level, the student may file an appeal with the Dean of the Graduate School. In a statement to the Dean, the aggrieved student must clearly state the substance of the appeal. The Dean of the Graduate School shall take all reasonable and proper actions to resolve the question or refer it directly to the Graduate Appeals Committee for its review. As a standing committee of the Commission on Graduate and Professional Studies and Policies, this committee will consist of three faculty members and one graduate student. For each appeal the dean shall appoint to the committee one additional faculty member knowledgeable in the academic area of the appeal. The review by the Graduate Appeals Committee will have available to it all pertinent information in the student's record in the university and (a) the department's policy statement concerning its degree expectations, (b) a summary of the department's action on the appeal, and (c) copies of the student's statement to the Dean of the Graduate School recording the student's view of alleged irregularities (i.e., the basis for university appeal). The Graduate Appeals Committee may hold a formal hearing on grievance appeals referred to it by the Dean of the Graduate School. The hearing will be conducted with the following procedural safeguards: 1. All parties to the dispute will be notified of the time and place of the hearing at least 48 hours in advance; 2. The aggrieved student will be permitted, if the student chooses, to invite a member of the faculty or student body to represent him/her in the hearing; 3. All parties in the dispute will be given full opportunity to testify and to present such evidence or witnesses as seem relevant; 4. All matters on which the finding will be based must be introduced into evidence at the hearing. The Graduate Student Appeals Committee will make a recommendation to the Dean of the Graduate School, which will be acted upon by the Dean of the Graduate School in consultation with the Provost. The Dean will convey the committee's recommendation and the final disposition of the matter to all concerned parties.

BIOMEDICAL AND VETERINARY SCIENCES

Emeriti Faculty: David Moore; Gerhardt Schurig;

Professors: S Ahmed; Virginia Buechner-Maxwell; Gregory Daniel; Marion Ehrich; Stephen Eubank; Jennifer Hodgson; Laura Hungerford; Kylene Kehn-Hall; Otto Lanz; Martha Larson; Tanya LeRoith; Margie Lee; David Lindsay; Xiang-Jin Meng; David Panciera; Kevin Pelzer; Robert Pleasant; Kerry Redican; John Rossmelst; Mohamed Seleem; Stephen Smith; Dan Sponenberg; Nammalwar Sriranganathan; William Swecker; Jeffrey Wilcke; David Wong; Lijuan Yuan; Anne Zajac; Kurt Zimmerman;

Associate Professors: Jonathan Abbott; Irving Allen; Orsolya Balogh; Jennifer Barrett; Sabrina Barry; Michele Borgarelli; James Brown; Christopher Byron; Clayton Caswell; Thomas Cecere; Sherrie Clark-Deener; Linda Dahlgren; Rebecca Funk; Julia Gohlke; Jia-Qiang He; Piedad Heno Guerrero; Ian Herring; Kathryn Hosig; William Huckle; Bradley Klein; Kevin Lahmers; Sunshine Lahmers; Xin Luo; Harold McKenzie; Albert Pan; Patrick Pithua; William Scarratt; Bonnie Smith; Michelle Theus; Sharon Witonsky; Hehuang Xie;

Assistant Professors: Ilektra Athanasiadi; Charlotte Baker; Sarah Barrett; Andrea

Bertke; Katie Boes; Sophie Bogers; Timothy Bolton; Ryan Calder; Julie Cecere; Kembra Clapp; Lisa Corcoran; Jennifer Davis; Stefanie Demonaco; Nikolaos Dervisis; Nisha Duggal; Shannon Farris; Mark Freeman; David Grant; Shawna Klahn; Tessa LeCuyer; Wen Li; Paul Morton; Noelle Muro; Jacquelyn Pelzer; Renata Ramos; Roxanne Rodriguez Galarza; Dominique Sawyere Hansford; Megan Shepherd; Jamie Stewart; Sharon Swanger; Joanne Tuohy; James Weger; Jennifer Zambriski;

Adjunct Professors: Blaise Costa; Theresa Hrubec; Christopher Reilly;

Associate Professor of Practice: Valerie Ragan;

Assistant Professor of Practice: Cassidy Rist;

Research Assistant Professors: Rujuan Dai;

Clinical: Sabrina Barry; James Brown; Rebecca Funk; Sunshine Lahmers; Noelle Muro; Roxanne Rodriguez Galarza; Megan Shepherd;

General Contact: cvmgrad@vt.edu

Graduate Contact: green15@vt.edu

General Contact: mctaylor@vt.edu

Biomedical & Veterinary Sciences: <https://bmvs.vetmed.vt.edu>

The Department of Biomedical and Veterinary Sciences (BMVS) is an integral part of the College of Veterinary Medicine and the Graduate School of Virginia Tech. The graduate program was initiated in 1986. In contrast to many departments and colleges on this campus, there is a single multidisciplinary graduate program for our college which is recognized by the Graduate School as a graduate department. The goal of this program is to train students to be creative and sophisticated research scientists in fields associated with biomedical research. The association with the College of Veterinary Medicine allows students the unique opportunity to explore both basic research, advanced pre-clinical animal model studies, natural clinical disease in animals, and translational research impacting both veterinary and human patients and populations. Our graduate program encourages collaborative, multidisciplinary research to achieve optimal health outcomes for people, animals, and the environment. To this end, we emphasize acquisition of a foundation of knowledge, research skills, and wet or dry laboratory experience required to implement independent research projects and develop the ability to formulate experimental and observational approaches to solve contemporary problems in the biomedical sciences. A basic philosophy of graduate education in biomedical and veterinary sciences is flexibility. Programs of study - courses, laboratory and field research, clinical experiences, and teaching opportunities - are tailored to meet the individual student's needs, depending on academic background, professional experience and career goals. The college prides itself on the high quality of faculty mentoring/advising, and support services.

SPECIAL FACILITIES

Faculty Research Laboratories are well equipped for modern molecular research and/or clinical studies. The following Core Research Service Laboratories are available to support the work of graduate students.

Analytical Research Lab

Center for One Health Research (COHR)

Electron Microscope Lab

Flow Cytometry

Glassware/Media Preparation

Quality Assurance Unit (Good Laboratory Practice)

Study Design and Statistical Analysis Lab

Teaching and Research Animal Care Support Service (TRACSS)

DEGREES OFFERED

MS Degree

Offered In (Blacksburg)

TOEFL

*iBT: Overall (90.0), Listening (20.0), Speaker (20.0), Reading (20.0),
Writing (20.0)*

GRE

*Minimum scores: Verbal Reasoning (150.0), Quantitative Reasoning
(150.0)*

IELTS

IELTS: Score (6.5)

The MS degree comprises a combined total of 30 credit hours of course work, research and thesis, and can be completed in two years.

PhD Degree

Offered In (Blacksburg)

TOEFL

*iBT: Overall (90.0), Listening (20.0), Speaking (20.0), Reading
(20.0), Writing (20.0)*

GRE

*Minimum scores: Verbal Reasoning (150.0), Quantitative Reasoning
(150.0)*

IELTS

IELTS: Score (6.5)

The PhD degree comprises a combined total of 90 credit hours of course work, research and dissertation. The PhD can be completed in four years. It is not required to have a Master's degree before entering the PhD program.

GRADUATE COURSES (BMVS)

BMVS 5005 (VM 9085):

Emerging Infectious Diseases

Stand-alone, fully on-line, asynchronous distance and distributed learning course, accessible as streaming videos on the internet or on CDs. 5005: The course defines and discriminates amongst numerous factors influencing the emergence of infectious diseases. Selected emerging food-borne, bacterial, viral, zoonotic diseases of animals and humans are described and analyzed. 5006: The course expands the pathology of emerging infectious diseases. Additional viral, parasitic and zoonotic diseases of animals and humans are described and analyzed. Xenotransplantation is also discussed from the perspective of zoonotic diseases. Third year standing in the DVM curriculum, or good standing in a graduate studies program is required.

Credit Hour(s): 1

Lecture Hour(s): 1

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

BMVS 5006:

Emerging Infectious Diseases

Stand-alone, fully on-line, asynchronous distance and distributed learning courses, accessible as streaming videos on the internet or on CDs. 5005: The course defines and discriminates amongst numerous factors influencing the emergence of infectious diseases. Selected emerging food-borne, bacterial, viral, zoonotic diseases of animals and humans are described and analyzed. 5006: The course expands the pathology of emerging infectious diseases. Additional viral, parasitic and zoonotic diseases of animals and humans are described and analyzed. Xenotransplantation is also discussed from the perspective of zoonotic diseases. Third year standing in the DVM curriculum, good standing in a graduate studies program is required.

Credit Hour(s): 1

Lecture Hour(s): 1

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

BMVS 5014:

Animal Pathology Residency

Training in diagnostic pathology through weekly rotations in the necropsy and surgical biopsy service of the teaching hospital. Students will perform necropsies and histopathologic examinations of necropsies and surgical biopsies and write diagnostic reports. The course is taken in weekly intervals of necropsy and/or surgical biopsy, with a credit hour

given for each 2-week interval. Variable credit. May be repeated with a maximum of 5 hours. DVM degree required.

Credit Hour(s): 1 TO 5

Lecture Hour(s):

Instruction Type(s): Lab

Instruction Type(s): Lab

Prerequisite(s):

Corequisite(s):

BMVS 5044:

Veterinary Immunology

Study of immunological mechanisms effective in protecting animals from infectious and foreign agents. Includes the use of immunological reactions for diagnostic purposes and the role of immune mechanisms in the induction of diseases.

Credit Hour(s): 2

Lecture Hour(s): 2

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

BMVS 5094 (FST 5094) (CHEM 5094):

Grant Writing and Ethics

A framework for writing clear, concise grant proposals in a team-oriented, multidisciplinary approach from concept development through submission to a funding agency. Potential ethical dilemmas that may arise in academic, industrial, or federal research settings will be discussed. PRE: Undergraduate courses in one of the following: organic chemistry (CHEM 2565/2566), cell and molecular biology (BIOL 2104), Concepts of Biochemistry (BCHM 2024), or equivalent. Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

BMVS 5124 (VM 8474):

Reproductive Pathology

Study of lesions of the reproductive system of domesticated animals. Relationship of these lesions to infertility and examination of the pathogenesis of the lesions and infertility.

Credit Hour(s): 1

Lecture Hour(s): 1

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ALS 4304 (UG) OR ALS 4304

Corequisite(s):

BMVS 5144:

Oncology Pathology

This course presents the pathology of neoplasms of all organ systems by using assigned reading, tutorials, tissue sections and discussion. Emphasis is on the clinical presentation, histologic diagnosis, and prognosis of each neoplasm. Formal lectures are not given. Independent study and twice weekly discussion sessions. DVM degree required.

Credit Hour(s): 2

Lecture Hour(s): 2

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): VMS 5134 (UG) OR VMS 5134

Corequisite(s):

BMVS 5154G:

Advanced Lab Animal Management

Advanced course involves a study of the principles of laboratory animal science, providing the student with a basic understanding of the laws and regulations governing the care and use of research animals, husbandry and surgery of a variety of lab animal species, and variables which can adversely affect animal research. Through formal lectures, discussions, and laboratory sessions, this course is designed to complement graduate studies in biological, biomedical, and life sciences which involved the use of animals in research. Graduate standing required.

Credit Hour(s): 0 OR 3

Lecture Hour(s): 0 OR 2

Instruction Type(s): Lab, Lecture, Online Lecture

Instruction Type(s): Lab, Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

BMVS 5174:

Responsible Research Conduct

Scientific integrity and responsible conduct of research as related to studies in life sciences, physical sciences, social sciences, engineering, and humanities. Conflict of interest, human and animal subjects in research, mentor/mentee responsibilities, collaborative research, peer review, research misconduct, responsible authorship and publication, data management, sharing, and ownership, and legal issues in research.

Pre: Graduate Standing.

Credit Hour(s): 1

20 Lecture Hour(s): 1

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

BMVS 5194:

Clinical Micropathology

This course presents practical topics in diagnostic pathology. It covers the entire spectrum of disease processes, including the background of clinical, gross anatomic physiologic information required for integration with the microscopic changes observed to arrive at a correct diagnosis.

DVM degree and permission of the instructor required.

Credit Hour(s): 1

Lecture Hour(s): 1

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

BMVS 5224 (BMES 5024):

Biomedical Engineering and Human Disease

Comprehensive overview of a variety of human diseases, including neurological disorders, cardiovascular disease, infectious disease, and cancer, designed primarily for graduate students majoring in engineering and other related areas who have a long-term academic and professional goal in the field of biomedical engineering and life sciences.

Introduction to state-of-the-art biomedical engineering approaches used for the study of early detection/diagnosis, treatment and prevention of human disease. Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): BMES 5004 OR BMVS 4064 (UG) OR BMVS 4064 OR BMES 4064 (UG)

Corequisite(s):

BMVS 5244:

Veterinary Pharmacology

Principles of pharmacodynamics and pharmacokinetics, including interaction of drugs with receptors; absorption, distribution and clearance; drug metabolism and drug interactions. Study of drugs by pharmacological classes, the general mechanisms of action, usefulness and side effects. Pharmaceutical calculations and prescription writing. May be repeated for a maximum of 5 credits. Pre-requisite: Graduate standing required

Credit Hour(s): 1 TO 5

Lecture Hour(s): 1 TO 5

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

BMVS 5274:

Systems Pathology

This lecture only course covers the pathology and pathogenesis of specific lesions and diseases of each organ system at the gross and microscopic level. Emphasis is on diagnostic characteristics and interpretation of diseases. Pre: DVM or equivalent.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

BMVS 5284:

Cellular Pathology

This course presents the mechanisms involved in cellular reaction to injury, inflammation, tissue repair and regeneration, circulatory disturbances (thrombosis, embolism, infarction, hemorrhage, edema, congestion, shock) and neoplasia and other alterations of cell growth. Emphasis will be placed upon disease processes at the cellular and tissue levels.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

BMVS 5324:

General Neurochemistry

Biochemical mechanisms involved in normal and abnormal nervous system function including discussions of experimental techniques, structural components, neurotransmitters, cerebral blood flow and metabolism, sensory systems, learning, mental disorders, and neuropharmacological agents.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): (BCHM 4116 (UG) OR BCHM 5124 (UG)) OR (BCHM 4116 OR BCHM 5124)

Corequisite(s):

BMVS 5364:

Ultrastructure Methodology in Biological Sciences

An introduction to the methodology of transmission electron microscopy as it applies to the life sciences. The goal of the course is to provide students who expect to use ultrastructure as a research tool with the fundamental principles behind the techniques, and hands-on experience in preparing and examining them in the electron microscope. Students prepare tissues and will generate a final project in the form of a journal article. Because of the intensive nature of the laboratory portion, course enrollment is limited to 15 students, and permission of the instructor is required.

Credit Hour(s): 0 OR 3

Lecture Hour(s): 0 OR 2

Instruction Type(s): Lab, Lecture, Online Lecture

Instruction Type(s): Lab, Lecture, Online Lecture

Prerequisite(s): BIOL 4504 (UG) OR BIOL 4504

Corequisite(s):

BMVS 5444:

Veterinary Anatomy II

Study of the structural and functional anatomy of carnivores (dog, cat), horses, and ruminants. Gross, developmental and radiographic morphology with applications for clinical diagnosis, interpretation, and surgical and medical treatment.

Credit Hour(s): 0 OR 4

Lecture Hour(s): 0 OR 2

Instruction Type(s): Lab, Lecture, Online Lecture

Instruction Type(s): Lab, Lecture, Online Lecture

Prerequisite(s): VM 8014 OR BMVS 5434 (UG) OR BMVS 5434

Corequisite(s):

BMVS 5454:

Veterinary Physiology I

Study of physiological functions in companion, food, fiber, laboratory, zoo, and wildlife animal species. Emphasizes fundamentals and the overview of cellular, organ, and regulatory integration. Topics include cells, muscles, blood, respiration, circulation, environmental and regulatory physiology.

Credit Hour(s): 0 OR 3

Lecture Hour(s): 0 OR 2

Instruction Type(s): Lab, Lecture, Online Lecture

Instruction Type(s): Lab, Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

BMVS 5464:

Veterinary Physiology II

Study of how living animals function. The central themes include close relationship between structure and function, process of adaptation, and the concepts of homeostasis and feedback control systems. The course focuses on the function of the tissues, organs, and organ systems of multicellular organisms.

Credit Hour(s): 4

Lecture Hour(s): 4

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

BMVS 5474:

Veterinary Neurobiology

Normal structure and function of the mammalian nervous system. Basic neuroanatomy, neurophysiology, neurochemistry, and neurohistology of sensory, motor, integrative, and regulatory systems will be discussed, as well as metabolic support systems.

Credit Hour(s): 0 OR 2

Lecture Hour(s): 0 OR 4

Instruction Type(s): Lab, Lecture, Online Lecture

Instruction Type(s): Lab, Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

BMVS 5564 (VM 8534):

Introduction to Clinical Research

Design of studies in veterinary related clinical research, planning and implementation of experimental and survey data collection, management and analysis of data, evaluation of analysis and critical evaluation of published information. Instructor approval required.

Credit Hour(s): 2

Lecture Hour(s): 2

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

BMVS 5574:

Advanced Poultry Diseases

An advanced course covering diagnosis, etiology, and treatment of poultry diseases. Diseases will be grouped by system affected, their common features detailed, and then unique characteristics of these diseases described.

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

BMVS 5594:

Current Technologies in Biomedical Sciences

Current methodologies and techniques for hypothesis-driven scientific experimentation in biomedical research, including molecular biology approaches, microscopy, animal models, molecular applications, cell culture systems, large-scale omics methodologies, bioinformatics analyses, and clinical studies. Cutting-edge and novel approaches for designing experiments and interpreting the resulting data; review of scientific literature; and important considerations for the appropriateness and limitations of specific methods, approaches, and experimental models. Pre: Graduate standing.

Credit Hour(s): 1

Lecture Hour(s): 1

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

BMVS 5604:

Principles and Methods in Equine Surgery

Graduate level course in advanced techniques in equine surgery. Activities include elucidation of pathophysiology, diagnosis, and surgical approach to complex equine conditions including nonroutine cases as they are presented. DVM degree required. Maximum 3 credits.

Credit Hour(s): 1 TO 3

Lecture Hour(s): 1 TO 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

BMVS 5614:

Principles and Methods in Equine Internal Medicine

Graduate level course in the application of advanced techniques in equine internal medicine. Activities will include elucidation of pathophysiology, performance of diagnostic methodology, and therapeutic management of complex medical disorders affecting the equine species. Course will be offered at the Marion duPont Scott Equine Medical Center. DVM Degree required.

Credit Hour(s): 0 OR 3

Lecture Hour(s): 0 OR 1

Instruction Type(s): Lab, Lecture, Online Lecture

Instruction Type(s): Lab, Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

BMVS 5624:

Molecular Virology

The principles and mechanisms of virus replication at the molecular level including transcription, translation and posttranslational modifications of virus genes, virus interaction with host, antivirals, vaccines and host defense mechanisms against virus infections. The replication and pathogenesis mechanisms of several important DNA and RNA virus families including biothreat viruses. Graduate standing required.

Credit Hour(s): 2

Lecture Hour(s): 2

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

BMVS 5704:

Veterinary Cytopathology

Interpretation of cytopathologic samples. Descriptive reports. Routine to complex case material from animal tissue specimens. Prerequisite: Third year standing in the DVM curriculum.

Credit Hour(s): 1

Lecture Hour(s): 1

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

BMVS 5714:

Biomedical Literature

This course deals with searching the literature in Biomedicine, both in printed form as well as computerized bibliographic databases. It also covers the topic of managing personal collection of published materials for effective retrieval. This course is for graduate students enrolled in biomedical research programs.

Credit Hour(s): 1

Lecture Hour(s): 1

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

Clinical Pathology

The study of relating abnormal clinical laboratory data to specific organ dysfunctions or lesions with emphasis on data interpretation and on understanding the pathophysiologic mechanisms leading to abnormal data. Additional emphasis will be placed on understanding the diagnostic and prognostic value of thoughtfully selecting pertinent laboratory tests to aid in the medical management of clinical cases. Alterations in the hematology, clinical chemistry, urinalysis, and cytology of the major domestic species will be studied.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

BMVS 5744:

Veterinary Parasitology

Study of the morphology and biology of parasites of veterinary importance. Considers of pathogenesis, diagnosis, signs, and treatment of parasitic diseases of animals. Study of the immunologic and pathophysiologic aspects of host/parasite relationships and the importance of zoonotic parasitic infections. II.

Credit Hour(s): 0 OR 3

Lecture Hour(s): 0 OR 2

Instruction Type(s): Lab, Lecture, Online Lecture

Instruction Type(s): Lab, Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

BMVS 5764 (VM 8494):

Aquatic Medicine and Fish Health

The etiology, diagnosis, pathology, pathogenesis, chemotherapy, control and management of infectious and non-infectious diseases of aquatic organisms, especially pertaining to cultured food and tropical fish. Hands on experience with water quality evaluation, diagnostic techniques and the identification of common pathogenic organisms. Pre-requisite:

Second year standing in the DVM curriculum.

Credit Hour(s): 2

Lecture Hour(s): 2

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): VM 8364 OR FIW 4514 (UG) OR FIW 4514

Corequisite(s):

BMVS 5794:

Clinical Neuropathology

This course uses necropsy tissues of clinical cases to present the mechanisms involved in neurologic disease of animals. Gross, microscopic, and radiologic approaches will be employed. Emphasis will be placed upon the correlation of clinical and pathological findings. May be repeated. Pre: Instructors approval required.

Credit Hour(s): 1

Lecture Hour(s): 1

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

BMVS 5814 (VM 8254):

Functional Morphology and Natural History of Reptiles and Birds

Anatomical features will be described that are unique to, or are characteristic of, each major group covered. Adaptation and successful exploitation of habitat. Use of anatomical features and functions.

Selected attributes of the groups natural history, members of the group common to the local and extended area, those commonly kept as pets.

Pre-requisite: Graduate Standing required.

Credit Hour(s): 1

Lecture Hour(s): 1

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

BMVS 5824:

Small Animal Nutrition

Practical feeding guidelines for companion animals. Special consideration also given to the relationship of diet to nutrient excesses and deficiencies that result in clinical disorders. Diagnosis, treatment, and prevention of metabolic disorders of companion animals will be discussed.

Credit Hour(s): 1

Lecture Hour(s): 1

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

BMVS 5834:

Food Animal Nutrition

Practical feeding guidelines for food animals. Special consideration also given to the relationship of diet to nutrient excesses and deficiencies that result in clinical disorders. Diagnosis, treatment, and prevention of metabolic disorders of food animals will be discussed.

Credit Hour(s): 2

Lecture Hour(s): 2

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): VM 8454

Corequisite(s):

BMVS 5844:

Equine Nutrition

The course is designed to provide practical feeding guidelines for different classes of horses. The relationship between nutrition and clinical disorders of the horse is explored including their nutritional management. Students will be expected to complete a problem-solving nutrition project during the course.

Credit Hour(s): 1

Lecture Hour(s): 1

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): VM 8454

Corequisite(s):

BMVS 5894:

Final Examination

NONE

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

BMVS 5904:

Project and Report

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Research, Online Research

Instruction Type(s): Research, Online Research

Prerequisite(s):

Corequisite(s):

BMVS 5944:

Seminar in Biomedical and Veterinary Sciences

Presentations by graduate students on current topics in Biomedical and Veterinary Sciences. Topics and responsibility for seminars is rotated among the professional departments of the college. Maximum 4 credits.

Credit Hour(s): 1

Lecture Hour(s): 1

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

BMVS 5954:

Study Abroad

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

BMVS 5974:

Independent Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Independent Study, VI

Instruction Type(s): Independent Study, VI

Prerequisite(s):

Corequisite(s):

BMVS 5984:

Special Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

BMVS 5994:

Research and Thesis

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research, Online Research

Instruction Type(s): Research, Online Research

Prerequisite(s):

Corequisite(s):

BMVS 6014:**Veterinary Clinical Sciences Residency**

Advanced course with training and instruction in veterinary patient management. Supervised practicum in veterinary diagnosis and therapy in a veterinary teaching hospital. Material will include development of knowledge and skills for problem solving, performance of techniques, and effective communication. Regularly scheduled rounds and conferences will supplement daily activities. 0 credit. DVM degree required.

Credit Hour(s): 0

Lecture Hour(s): 0

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

BMVS 6064:**Advanced Topics in Veterinary Medicine**

Students will critically review and actively participate in discussion of current and important historic veterinary and comparative medical literature relevant to students residency specialty. DVM degree is required. May be repeated with different content for a maximum of 12 credit hours.

Credit Hour(s): 1 TO 6

Lecture Hour(s): 1 TO 6

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

BMVS 6074:**Clinical Topic Rounds**

Practical, advanced training in specialty medicine. Students will participate in critical reviews of cases and current literature applicable to selected cases. Relevant information will include advanced diagnostic and therapeutic techniques applicable to the specialty and species being studied. An in-dept knowledge of the pathophysiology of animal disease processes and clinical problem solving will be developed. Students will be expected to gain an understanding of the general problem area to be studied and critically evaluated current literature and application to the case(s) being studied. DVM degree is required. May be repeated with different content for a maximum of 12 credit hours.

Credit Hour(s): 1 TO 6

Lecture Hour(s): 1 TO 6

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

BMVS 6084:**Veterinary Speciality Clinics**

Practical, advanced training in specialty medicine. Students will learn advanced diagnostic and therapeutic techniques applicable to the specialty and species being studied. An in-depth knowledge of the pathophysiology of animal disease processes and clinical problem solving will be developed. Students will be given responsibility for case management with faculty guidance. DVM degree is required. May be repeated for a maximum of 12 credits with different content.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

BMVS 6094:**Board Certification Topics**

Structured preparation for the specialty examinations associated with residency programs and board certification. Topics will vary depending on the particular learning objectives required by the clinical discipline. Pre-requisite: Graduate standing and clinical resident in the Virginia Maryland Regional College of Veterinary Medicine. May be repeated for up to 6 credit hours with different content.

Credit Hour(s): 1

Lecture Hour(s): 1

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

BMVS 6114:**Neurogenesis in the Developing and Diseased Brain**

Development, maintenance and injury-induced response of stem cells in the brain. Key epigenetic and signal transduction pathways required for the proper development and adaptive response of stem cells in the neurogenic compartments after brain injury in rodents and larger animal species.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

BMVS 6514:**Equine Theriogenology I**

An advanced study in the breeding management, estrous cycle manipulation, embryo transfer, parturition and the foaling issues, reproductive disease diagnoses and treatment of the mare and stallion. Practical application of the latest research covered in this species. Pre: Second-year standing in the DVM curriculum.

Credit Hour(s): 1

Lecture Hour(s): 1

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): VM 8634 OR (ALS 4304 (UG) OR ALS 4304)

Corequisite(s):

BMVS 6534:**Mechanisms of Disease in Veterinary Medicine**

Advanced study of topics concerning the pathophysiology, diagnosis, and current therapy of diseases in Veterinary Medicine. Pre: DVM or equivalent, or consent of instructor. May be repeated to a maximum of 18 credits.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

BMVS 6554:**Advanced Epidemiology**

This course is intended for students interested in applying analytical epidemiological methods in assessing the health and disease status of populations (animal and/or human) and the factors affecting that status. It will include lecture/discussion sessions and exercises on the design, analysis, and interpretation of clinical trials and cross-sectional, case-control, and longitudinal studies. Risk assessment and techniques for assessing and enhancing the validity of epidemiological studies will also be covered. Pre: third-year standing in the DVM curriculum.

Credit Hour(s): 2

Lecture Hour(s): 2

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

BMVS 6564:**Advanced Veterinary Public Health**

Consideration of the organization and delivery of Veterinary Public

Services at the local, state, national and international levels including zoonoses surveillance, investigation and response to disease outbreaks, biological warfare and terrorism, response to natural emergencies and disasters, and public health policy formulation. Pre: third-year standing in the DVM curriculum.

Credit Hour(s): 1

Lecture Hour(s): 1

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

BMVS 6594:**International Veterinary Medicine**

Overview of international veterinary activities. Understanding of the role of governmental agencies, inter-governmental and non-governmental organizations in international relations, development, relief work, conservation, disease control and prevention, and trade. Understanding of the legal authority of binational agreements and international treaties. Training in intercultural communications, negotiation and conflict resolution. Review of current global issues. Pre: third-year standing in the DVM curriculum.

Credit Hour(s): 2

Lecture Hour(s): 2

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

BMVS 6714:**Immunology in Health & Disease**

Analysis of emerging, cutting edge and paradigm changing concepts of cellular and molecular immunology in human and animal health and disease. Innate immunity, adaptive immunity, developmental immunology, autoimmunity, immunodeficiency, cancer immunology, and transplantation immunology.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): BIOL 5734 OR BCHM 5124

Corequisite(s):

BMVS 6724:**Mol Mech of Path Bacteria**

Molecular mechanisms employed by pathogenic bacteria to cause infection. Classical and contemporary methods for studying host-

pathogen interactions at the molecular level. Hypothesis-driven scientific experimentation in pathogenic bacteriology.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): BIOL 5634 OR BIOL 5674

Corequisite(s):

BMVS 6984:

Special Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

BMVS 7994:

Research and Dissertation

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research

Instruction Type(s): Research

Prerequisite(s):

Corequisite(s):

BUSINESS, ACCOUNTING AND INFORMATION SYSTEMS

John Maher, Head

Professors: Reza Barkhi; France Belanger; Sudip Bhattacharjee; John Maher; Steven Sheetz;

Associate Professors: Ling Lisic; David Tegarden; Linda Wallace;

Assistant Professors: Andrew Acito; Matthew Cobabe; Robert Davidson; Cintia Easterwood; Matthew Erickson; Dana Garner; Michelle Harding; Sean Hillison; Jingjing Huang; Eugene Johnson; Michelle Lowry; Sarah Stein; Liang Tan;

Marshall Vance; Kimberly Walker;

Visiting Faculty: Jeffrey Pittman;

R. B. Pamplin Professor: France Belanger;

KPMG Professor: Reza Barkhi;

Thomas M. Wells and Kathy Dargo Professor: Sudip Bhattacharjee;

John F. Carroll, Jr. Professor: John Maher;

Associate Professor of Practice: Nadia Rogers;

General Contact: acis@vt.edu

Graduate Contact: amita@vt.edu

Graduate Site: <http://graduateschool.vt.edu>

Department Site: <http://www.acis.pamplin.vt.edu>

The Department of Accounting and Information Systems offers programs of graduate study leading to the degrees of Master of Accounting and Information Systems and Ph.D. in Business with concentration in Accounting and Information Systems.

SPECIAL FACILITIES

–

DEGREES OFFERED

MACIS Degree

Offered In (Blacksburg)

TOEFL

IBT: (105.0), (0.0)

Computer: (260.0)

iBT: (105.0)

GMAT

: Total (520.0)

Master of Accounting and Information Systems Program The Master of Accounting and Information Systems Program (MACIS Program or Program) provides graduate level education for professional careers in accounting and information systems. It is especially appropriate for those individuals planning to become a CPA and enter professional accounting. For those planning to enter a Ph.D. program, the Program offers the necessary foundation. The MACIS Program is open to students with a bachelor's degree in any discipline. For those who have fulfilled the background requirements, the Program consists of 30 semester hours and can normally be completed in 12 months of coursework. Students without prior collegiate studies in accounting, information systems, and/or business administration can expect to spend additional time in the Program completing prerequisites. The MACIS Program offers five Options designed to prepare students for different types of careers: Accounting Analytics, Audit, Tax, Financial Services and Information Systems. Accounting Analytics provides students with a degree grounded in applying state-of-the-art analytics concepts, techniques, and software to help solve accounting and assurance problems. Audit prepares students to effectively practice as accountants or auditors within a company or public accounting firm, ranging in size from small to Fortune 500 companies and other large entities. Tax prepares students to provide tax return preparation and consultation services in the tax department of companies or large public accounting firms. It also prepares students to perform these services in smaller public accounting firms where they are likely to perform both audit and tax services. Financial Services provides students with an analytical perspective from which he/she can effectively examine key business decisions related to financial markets and institutions and advise clients accordingly. Finally, Information Systems prepares students to work within the Advisory Practice of a

large professional services firm or in the information technology department within a company. Courses generally offered include: ACIS 5014 Information Systems Audit and Control ACIS 5104 Fundamentals of Accounting ACIS 5124 Governmental and Nonprofit Accounting ACIS 5194 Financial Statement Analysis* ACIS 5214 Advanced Strategic Cost Management ACIS 5314 Tax Concepts and Research ACIS 5324 Taxation of Business Entities* ACIS 5334 Advanced Corporate Tax ACIS 5364 Multi-jurisdictional Tax Concepts ACIS 5414 Auditing Theory* ACIS 5424 Research and Analysis in Accounting* ACIS 5444 Forensic & Investigative Accounting ACIS 5504 Sys/Database Concepts ACIS 5524 Advanced Database Management Systems ACIS 5534 Information Systems Development ACIS 5584 Information Systems Security and Assurance ACIS 5654G Advanced Accounting Analytics* ACIS 5754 Accounting Internship BIT 5424 Advanced Business Info Viz/Analytics BIT 5534 Applied Business Analytics and Intel II FIN 4264 Managing Risk with Derivatives FIN 4274/5124 Investment Analysis/Portfolio Management FIN 5194 Commercial Law *Course required under all Options

PhD Degree

Offered In (Blacksburg)

GMAT

: Total (650.0)

TOEFL

Paper: (650.0)

iBT: (115.0)

The program leading to the Ph.D. in business with a concentration in accounting and information systems (ACIS) permits the student to pursue advanced graduate studies in preparation for a career in university teaching and research. The first two to three years of the Ph.D. program are devoted to course work. The program's basic requirements include core course work in accounting and research methods, as well as course work in a supporting area and statistics. The remainder of the time is devoted to the dissertation and development of coauthored research papers. There is no foreign language requirement, although computer proficiency is expected. The following specific courses are required in the major field: ACIS 5974, 6004, and two of the following: 6014, 6024, and 6504. Depending on a student's background and research method interest, additional ACIS courses will be required. Each candidate for the Ph.D. in business with a major in accounting and information systems must pass the first and second year research paper requirements, a written examination at or near the completion of course work, defend a dissertation proposal before the accounting and information systems faculty, and pass a final oral examination after the dissertation is completed.

GRADUATE COURSES (ACIS)

ACIS 5014:

Information Systems Audit and Control

This course explores the theories and practices of audit and control of computer-based information systems. Audit and control of information systems is examined from the viewpoint of management, systems professionals, and auditors. The rationale for controls, control theories,

and audit practices are emphasized. Graduate Standing Required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ACIS 3504 (UG), ACIS 4414 (UG)

Corequisite(s):

ACIS 5044:

International Issues in Accounting

Accounting issues related to international business activities and foreign operations. Comparative effects of U.S. and international accounting standards on financial reporting and analysis of financial statements. Effects of multijurisdictional taxation on business structures and transactions and impacts of foreign currency translation on financial and commercial markets and related risks. Audit and governance standards in international business. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ACIS 5104:

Fundamentals of Accounting

Fundamentals of accounting systems as they relate to decision making. Attention is directed toward accounting for the core of management control and financial reporting systems, and as integrally related to the information system. Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ACIS 5124:

Governmental and Nonprofit Accounting

An analysis of current governmental and nonprofit accounting, budgeting, reporting, and auditing concepts, models, and practices. Identification and evaluation of alternative concepts and models will also be emphasized. Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

29 Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

ACIS 5144:

Financial Statements for Managers

Use and analysis of financial accounting information. Business decisions based on advanced statistical analysis of financial data. Estimation of company value, past performance, and forecasted future performance. Impact of operating, investing, and financing activities. Pre: Graduate standing.

Credit Hour(s): 2

Lecture Hour(s): 2

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ACIS 5154:

Analyzing Financials and Implementing Controls

Financial statement analysis as an aid to decision making. Investing and lending decisions as they affect financial statement users of domestic, global, and entrepreneurial companies. Analysis and design of control systems to accomplish short-term objectives and enable management attention on long term strategic issues.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ACIS 5104

Corequisite(s):

ACIS 5194:

Financial Statement Analysis

A comprehensive treatment of the analysis of financial statements as an aid to decision making. Primary attention is placed on investing and lending decisions as they affect the financial manager.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ACIS 5104

Corequisite(s):

ACIS 5214:

Advanced Strategic Cost Management

To provide an understanding of advanced strategic cost management methods. The areas covered include topics in cost estimation, cost-

volume-profit analysis, activity based costing, costing in new manufacturing environments, performance measurement, management control, and ethical implications. Graduate Standing Required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ACIS 4214 (UG) OR ACIS 4214

Corequisite(s):

ACIS 5294:

Management Control Systems

Analysis and design of control systems to facilitate short term decisions in order to allow management attention on long term strategic issues. Such systems integrate financial, marketing, production, and other business policies in accomplishing the goals and objectives of an organization. Accounting techniques are the core of management control systems, and information systems provide necessary links. Includes impact of tax planning, financial reporting, and internal and external auditing systems.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ACIS 5104

Corequisite(s):

ACIS 5314:

Tax Concepts and Research

Tax research process including analysis of fundamental tax concepts underlying interpretation and application of tax law, mechanics of tax research, written and oral communication of research results, tax planning, and practice and procedure before tax authorities. The course explores the sources and hierarchy of tax law and the interaction of law and its interpretation and application to contemporary tax issues, as well as the recognition of the impact on and opportunities for future tax planning. Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ACIS 3314 (UG)

Corequisite(s):

ACIS 5324:

Taxation of Business Entities

30 The tax aspects of forming and operating partnerships and corporations,

and the sale and liquidation of a partnership interest. Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ACIS 3314 (UG)

Corequisite(s):

ACIS 5334:

Advanced Corporate Tax

Covers the tax aspects of corporate redemptions, liquidations, and reorganization. The law of consolidated tax returns will also be covered.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ACIS 5324

Corequisite(s):

ACIS 5364:

Multi-jurisdictional Tax Concepts

Tax issues of business enterprises operating in multiple taxing jurisdictions; multi-state and international taxation will be discussed.

Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

ACIS 5414:

Auditing Theory

An in-depth study of the auditing profession. Topics include professional standards, independence, business and risk analysis, regulation of the profession, and advanced reporting issues. Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ACIS 4414 (UG) OR ACIS 4414

Corequisite(s):

ACIS 5424:

Research and Analysis in Accounting

Analysis and research of potential solutions to complex accounting and

financial reporting problems. Problem-solving using professional accounting standards databases and academic accounting research.

Verbal and written communication of research findings and recommendations. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

ACIS 5444:

Forensic and Investigative Accounting

Forensic Accounting is a specialized area of accounting which uses accounting methods and financial techniques to assist in solving economic-based crimes. This course will provide students an opportunity to gain experiences in forensic accounting as well as commonly used computer forensic software and techniques. The focus is on litigation support, fraud risk management, fraud investigation, and the related audit tools. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ACIS 3115 (UG)

Corequisite(s):

ACIS 5504:

Information Systems Design and Database Concepts

This course is an introduction to design methodologies in information systems. Structured systems analysis and design methodologies are discussed. An introduction to database design methodologies is also included. Topics related to different database models and their implementation is discussed. Students are also required to design and implement information systems using appropriate computer software. Pre: MBA/MACCT standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ACIS 5514:

Management of Information Systems

An analysis of theories and practices used in the management of systems that generate information and decisions to coordinate and

control business operations. Both the viewpoints of the manager and the systems professional are covered in this course. Graduate Standing Required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

ACIS 5524:

Advanced Database Management Systems

This course relates database theories and practices to concepts from other areas, such as programming languages, algorithms, data structures, and information systems. The relational, network, and hierarchical models are introduced. A major portion of the course deals with data manipulation languages for the relational model, design theory for relational databases, and query optimization.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ACIS 5504

Corequisite(s):

ACIS 5534:

Information Systems Analysis and Design

Modeling of semantically-driven information systems. Object-oriented (OO) requirements definition, analysis, modeling, and design. Application of unified modeling language (UML) techniques for development of OO designs of information systems in complex business situations. Development of use cases, activity diagrams, sequence and communication diagrams, class hierarchies, behavioral state machines, package diagrams, object persistence formats, navigation diagrams and deployment diagrams. Management of the systems development process, including the spiral construction and implementation phases of the process. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

ACIS 5574 (BIT 5574):

Healthcare Data Management

Organization and management of data in the health care industry.

Includes standards for electronic health records, healthcare enterprise systems architecture, health database design, existing database platforms, data integration from multiple sources, and database accessibility. Analysis of health-care-related organizations from the perspective of multiple user groups including patients, technicians, nurses, physicians, clinics, hospitals, and insurance companies.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): BIT 5564

Corequisite(s):

ACIS 5584:

Info Sys Security & Assurance

An examination of the concepts, technologies, and applications of security in information systems. Topics include cryptography; security and threats to computers, e-mail systems, and internet networks; intrusion detection systems; and e-business security. Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

ACIS 5604:

Accounting Fundamentals

An introduction for practicing executives to financial accounting cycles and transactions, financial statement reporting, and internal managerial accounting and costing. This course is designed to give executives an understanding of accounting systems, and to illustrate and highlight potential points at which the systems could be manipulated. Executive MBA students only.

Credit Hour(s): 2

Lecture Hour(s): 2

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ACIS 5614:

Implementing Management Controls

The management control process is designed to influence managers and other employees of an organization to implement the strategies of the organization. The activities of management control include: planning,

coordinating, communicating, and evaluating. This course addresses the important role that accounting and other information play in this process.

Executive MBA students only.

Credit Hour(s): 2

Lecture Hour(s): 2

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ACIS 5624:

Cybersecurity Governance and Risk Management

Cybersecurity governance and risk management programs in organizations. Governance frameworks for cybersecurity and external drivers for cybersecurity. Risk management, including existing frameworks, principles, and strategies related to risk assessment and implementation of cybersecurity policies, controls, and procedures. Budgeting and evaluation of risk management programs. Compliance with organizational cybersecurity programs, including risks of insider threats, management of security-related personnel, and establishment of cyber hygiene. Cybersecurity governance in relation to cybersecurity regulation.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ACIS 5654G:

Advanced Accounting Analytics

Design and development of accounting systems using relational database management tools. Extraction and analysis of accounting data using queries, analytics, and visualization techniques. Application of accounting data analytics concepts using commercially available tools such as audit management software and current visualization tools. Proper preparation of data and use of analytics algorithms and visualization techniques to inform decision making. Pre: Graduate Standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ACIS 5704:

Managing Information for Executive Decision Making

An overview of the theories, practices, and technologies used in the management of information systems for business decision making. Topics include use of information systems, electronic business, business intelligence tools and knowledge management, customer relationship management systems, data warehousing, virtual teams and organizations, and information security and privacy, and their role in improving organizational decision-making capabilities. Graduate standing in EMBA or PMBA program required.

Credit Hour(s): 2

Lecture Hour(s): 2

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ACIS 5754:

Internship in Accounting

Full time, supervised internship experience at a public accounting firm, private company or governmental or nonprofit entity to gain practical, professional experience. Focus on advanced accounting concepts, procedures, and problem-solving tools applied in real-world environment through both individual and group work. Reporting on insights obtained during internship experience.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ACIS 5444 OR ACIS 5324 OR ACIS 5194

Corequisite(s):

ACIS 5894:

Final Examination

NONE

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ACIS 5954:

Study Abroad

NONE

Credit Hour(s): 1 TO 6

Lecture Hour(s): 1 TO 6

33 Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ACIS 5964:

Field Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ACIS 5974:

Independent Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Independent Study, VI

Instruction Type(s): Independent Study, VI

Prerequisite(s):

Corequisite(s):

ACIS 5984:

Special Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ACIS 5994:

Research And Thesis

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research, Online Research

Instruction Type(s): Research, Online Research

Prerequisite(s):

Corequisite(s):

ACIS 6004:

Accounting and Information Systems Research Methods

A doctoral level seminar emphasizing the understanding and application of research methods used in Accounting and Information Systems Research. Course activities concentrate on initiating doctoral students to the perspectives, methods, techniques, and skills necessary for conducting research in the Accounting and Information Systems disciplines. Topics covered include philosophy of science, the nature of theory, research methods, study design, and measurement. Students evaluate and present research from current journals, develop research proposals, and write a literature review for a topic of their choice. Doctoral standing is required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

ACIS 6014:

Behavioral Research in Accounting Seminar

A doctoral level seminar emphasizing the design and evaluation of research conducted in the behavioral research area of accounting. The primary emphasis is on behavioral decision theory and its applications to the accounting function. Primary seminar material is selected from recent journal articles and current working papers on relevant topics. Requires development and presentation of research proposal related to behavioral research in accounting.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ACIS 6004 (UG) OR ACIS 6004

Corequisite(s):

ACIS 6024:

Financial Capital Markets in Accounting Seminar

A doctoral level seminar emphasizing the design and evaluation of research conducted in the financial capital markets area of accounting. Concentrates on empirical markets-based research concepts and methodologies utilized in accounting. Primary seminar material is selected from recent journal articles and current working papers on relevant topics. Requires development and presentation of research proposal related to capital markets in accounting.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ACIS 6004 (UG) OR ACIS 6004

Corequisite(s):

ACIS 6044:

Seminar in Archival Audit Research

Review and critique of seminal journal articles and working papers that examine audit quality using archival research methods. Theoretical development of research questions on audit quality and application of rigorous research designs on the determinants and consequences of audit quality. Research inquiry and archival methods for audit quality.

Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ACIS 6984:

Special Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ACIS 7994:

Research And Dissertation

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research, Online Research

Instruction Type(s): Research, Online Research

Prerequisite(s):

Corequisite(s):

BUSINESS ADMINISTRATION

Parviz Ghandforoush, Head

Professors: Sudip Bhattacharjee; Kevin Carlson; Dipankar Chakravarti; Parviz Ghandforoush; Mahmood Khan; Raman Kumar; Sattar Mansi; Cliff Ragsdale;

Associate Professors: Wade Baker; William Becker; Donald Hatfield; Barbara Hoopes; Tabitha James; Raymond Major;

Professor of Practice: David Simpson;

General Contact: mba@vt.edu

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Graduate Programs: <http://www.mba.vt.edu>

Program Site: <https://cbia.pamplin.vt.edu/masters/admission.html>

Program Site: <http://www.htm.pamplin.vt.edu/>

The Pamplin College of Business offers graduate level programs in Blacksburg on the main campus, at the extended campuses in the greater Washington, D.C. metropolitan area and other locations in Virginia. The Master of Business Administration (MBA) degree program has three program formats (options): Evening (part- or full-time) based in Falls Church, Executive with classes in Arlington, and Professional with cohorts meeting in Roanoke and Richmond. The plan of study leading to the Master of Business Administration degree is a 48-credit program (49 for Executive) requiring a Bachelor of Science or Bachelor of Arts degree from an accredited college or university. Faculty teaching in the Evening MBA program are members of the following departments in Pamplin; Accounting & Information Systems, Business Information Technology, Finance, Hospitality and Tourism Management, Management, and Marketing. The MBA degree program offered by the Pamplin College of Business is fully accredited by the Association to Advance Collegiate Schools of Business (AACSB International). The Master of Science in Business Administration (MSBA) with a concentration in Hospitality and Tourism Management is offered primarily at the Northern Virginia Center in Falls Church, Virginia but with availability via online capabilities on our Blacksburg campus. The Master of Science in Business Administration with a concentration in Business Analytics is offered at the Blacksburg campus.

SPECIAL FACILITIES

National Capital Region Virginia Tech in the Washington, D.C. metropolitan region is dedicated to furthering the university's three missions – education, research, and outreach. With facilities, faculty, graduate degrees, and research in the region since 1969, Virginia Tech has a long tradition of creating new knowledge and applying it to the critical problems facing the Washington, D.C. area, the Commonwealth of Virginia, the nation, and the world. The MBA in the NCR has program options in Falls Church and Arlington Centers. MBSA-Hospitality and Tourism Management classes are taught in the Falls Church location. Commonwealth Campus Centers The Professional MBA is taught at the Richmond and the Roanoke Centers. Pamplin Hall The MSBA-Business Analytics courses are taught on the main campus in Blacksburg at Pamplin Hall.

Falls Church, Arlington and Richmond, Roanoke Centers

The Graduate Programs offices are housed at the Northern Virginia Center in Falls Church at 7054 Haycock Road, just across from the West Falls Church metro station, and near Rt. 7, I-66 and I-495. The Evening MBA program holds classes at the Northern Virginia Center in Falls Church. The Executive MBA program holds classes at the Virginia Tech Research Center in Arlington at 900 N. Glebe Road, near the Ballston stop of the metro and off I-66. Professional MBA courses are held at the Richmond and Roanoke Virginia Tech centers in alternating

in the Falls Church location.

Pamplin Hall, Room 1030

Classes for the MSBA-Business Analytics degree are taught in Blacksburg in Pamplin

Hall: <https://vt.edu/about/locations/buildings/pamplin-hall.html>

DEGREES OFFERED

MBA Degree

Offered In (Roanoke, Richmond, National Capital Region)

TOEFL

iBT: (90.0)

GRE

General: Verbal (154.0), Quantitative (154.0)

GMAT

: Total (600.0)

Three program options (formats) of EvMBA, EMBA and PMBA. Completion of 48 credit hours of coursework (49 for EMBA), 3.0 undergraduate GPA, GMAT/GRE for EvMBA, and PMBA programs. Evening MBA - flexible part- or full-time program, classes in the evening, fall and spring start. Located in Falls Church, VA. <https://evening.mba.vt.edu/index.html> Executive MBA - cohort based, classes on alternating weekends, fall start only. Located in Arlington, VA. <https://executive.mba.vt.edu/index.html> Professional MBA - cohort based, one weekend/month classes, fall start only. Located in Richmond and Roanoke, VA. <https://professional.mba.vt.edu/index.html>

Degree Concentrations:

Available in the Evening MBA program

Business Intelligence/Analytics, Cybersecurity Management, Entrepreneurial Leadership, Financial Management, General Management, Global Business, Health Information Technology, Hospitality & Tourism Management, Information Technology Management, Organizational Leadership, Dual degree option with Master of Information Technology degree, Dual degree option with Master of Science in Business Administration - Hospitality and Tourism Management degree

MS Degree

Offered In (Blacksburg, National Capital Region)

TOEFL

iBT: (90.0)

MSBA-Business Analytics: The program requires the completion of 30-credit hours including a 15-hour business core and 15-hour analytics core, including two courses directly related to a corporate sponsored capstone project. cbia.pamplin.vt.edu MSBA-Hospitality and Tourism Management: The MS in Business Administration (MSBA) with a concentration in Hospitality and Tourism Management is located in the greater Washington, D.C. metro area, the nation's hub for hospitality business; it is offered exclusively at the Virginia Tech Northern Virginia

Center in Falls Church, VA. The MSBA is a professional degree designed to either help students advance their professional career in HTM or as an important step to pursuing a Ph.D. and a subsequent academic career. <https://htm.pamplin.vt.edu/graduate/msba.html>

Degree Concentrations:

Business Analytics

The concentration in business analytics in the Master of Science in Business Administration (MSBA-BA) is designed to give students from multiple disciplines the necessary business knowledge, technical expertise, and professional skills to be effective business analytics practitioners. Admission to the program is competitive with selected based on leadership and communication skills, motivation and quantitative aptitude and computing experience. Undergraduate students who want to pursue an accelerated program or graduating students who are interested in pursuing a graduate degree may apply for the program. Students from all majors can apply. The application process includes the following: Online application via graduate school (\$75 non-refundable fee) Application Deadline: November 1 (Late application will be processed as space allows) Transcripts GMAT or GRE scores TOEFL or IELTS scores (for international students) Academic and Professional Goals Essay Resume with 3 references and contact information ~2 minute introductory video sharing how you heard of the MSBA-BA program and two things that differentiate you from other MSBA-BA applications (*A video produced via cell phone is sufficient) Applicant interview (qualified applicants will be contacted to schedule an interview after the online application has been reviewed) Cumulative minimum 3.0 GPA or better is desired The capstone project is the cornerstone activity of the Master of Science in Business Administration with a concentration in Business Analytics (MSBA-BA program). It is essential to the learning that takes place during the intensive year-long curriculum. Students work on interdisciplinary, four-to-five member teams on a corporate project that has significant strategic importance to corporations. At the end of the project, students will prepare a professional consulting report that summarizes and supports their findings and builds a business case for their recommendations. They will also make a formal presentation. Corporations provided data and a project coordinator. Students will gain experiential learning and apply classroom learning to real-world problems. This experience will not only enhance students' technical skills, but provided business acumen that facilitates execution of those skills.

BUSINESS, BUSINESS INFORMATION TECHNOLOGY

Roberta Russell, Head

Professors: Ralph Badinelli; Parviz Ghandforoush; Paul Lowry; Cliff Ragsdale; Terry Rakes; Loren Rees; Roberta Russell; Bernard Taylor; Christopher Zobel;
Associate Professors: Alan Abrahams; Idris Adjerid; Jason Deane; Barbara Hoopes; Tabitha James; Lara Khansa; Raymond Major; Lance Matheson; Quinton Nottingham; Onur Seref; Alan Wang;

Assistant Professors: Vitali Mindel; Wenqi Shen;

Ralph Medinger Lenz Professor: Ralph Badinelli;

Bank of America Professor: Cliff Ragsdale;

William C. and Alix C. Houchens Professor: Terry Rakes;

Arthur Andersen Professor: Loren Rees;

R.B. Pamplin Professor: Bernard Taylor; Christopher Zobel;

Collegiate Associate Professors: Wade Baker; Michelle Seref;

Suzanne Parker Thornhill Professor: Paul Lowry;

Graduate Contact: paul.lowry.phd@vt.edu

Graduate Site: <https://bit.vt.edu/academics/graduate-programs.html>

The PhD in Business with a concentration in Business Information Technology is designed to be a full-time, four-to-five year, residential program offering specialized study in information systems and technology, business analytics, security, and operations and supply chain management. The program emphasizes the study of systems and technologies used in the creation, storage, exchange, analysis, and use of information in organizational decision making. Considerable emphasis is given to the use of statistics, data science, machine learning, experimentation, surveys, field studies, and theory building. Study of these topics requires that the student have a strong background in quantitative methods and computing, but also strong conceptual thinking, creativity, and writing skills. The primary objective of the program is to prepare graduate students for successful academic careers in tenure-track positions that value high-quality research and teaching. This objective is realized through a research-oriented program of study that provides extensive interaction with our faculty of outstanding researchers and teachers.

SPECIAL FACILITIES

The Department of Business Information Technology is located in Pamplin Hall with its main office in room 1007.

DEGREES OFFERED

PhD Degree

Offered In (Blacksburg)

TOEFL

iBT: (100.0)

Paper: (600.0)

Computer: (250.0)

Responsibility for the administration of the PhD in Business with a concentration in Business Information Technology is shared by the Department of Business Information Technology, the Pamplin College of Business, and the Graduate School. General university graduate degree requirements, procedures, and policies, are available through the

Graduate School's web site <http://graduateschool.vt.edu/>. Applicants to the PhD in Business with a concentration in Business Information Technology must complete and submit scores for the GMAT exam. There is no minimum required GMAT score, but full GMAT exam results must be provided. All Ph.D. candidates must complete a minimum of 90 semester hours beyond the baccalaureate. This total must include a minimum of 60 semester hours of approved course work and no fewer than 30 hours of research and dissertation credits. At least 50 percent of all graduate course credits (excluding research and dissertation credits) must be earned at Virginia Tech. The program of study must also satisfy the following departmental requirements:1. An 18 hour core is required of all PhD students in the Department of Business Information Technology with an additional 12 to 15 hours of courses depending on the student's chosen research methods track.2. At least two continuous years must be spent in residence on the Blacksburg campus as a full-time student. A minimum of 24 graduate-level semester credit hours must be earned during this period.3. Successful completion of a departmental screening exam at the end of the first year. 4. Successful demonstration of research potential by the end of the second year. 5. Full instructional responsibility for a least one course during doctoral studies, subject to departmental needs. 6. Completion of Pamplin College workshops in Ethical and Scholarly Research Practices, and Inclusion and Diversity. Each student's formal program of study is prepared during the second or third semester of study. This plan is developed by the student in conjunction with the Ph.D. advisory committee. In formulating the program, attention is given to the student's prior academic preparation and career objectives.

GRADUATE COURSES (BIT)

BIT 5114:

Crime and Conflict in Cyberspace

In-depth exploration of the cyber threat landscape and the motives, methods, and mechanisms that shape it. Complex and evolving nature of security, privacy, policies and safety in cyberspace. Consequences posed by cyber threats at the individual, corporate, national, and societal levels. Cyber threat research, governance and analysis. National and international policies and strategies for protecting cyberspace.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

BIT 5124:

Cyberlaw and Policy for Information Technology

Key legal, ethical, and policy cyber governance and cyber security topics for managers and information security officers. Legal rights, remedies, and limitations related to cybercrime, computer intrusion, national security, and data breaches. Privacy laws and standards, impact assessments, privacy and security by design as policy and legal

requirements. Comparison of international approaches to relevant laws and policies. Fundamentals of managing legal and policy aspects of information technology and security. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

BIT 5134:

Cybersecurity Program Design and Operations

Development and maintenance of the enterprise cybersecurity life-cycle.

Design of a comprehensive and resilient cybersecurity program in alignment with business objectives. Implementation and management of security operations. Security assessments and remediation of deficiencies. Security intelligence, analytics, and incident response.

Measurement and communication of program effectiveness. Pre:

Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

BIT 5324:

Predictive Analytics & Data Mining for Executives

Implementation of predictive analytics and data mining to support business decisions. Building analytics capability within an organization.

Data exploration, cleaning, and visualization. Use of a structured methodology for data mining practice. Supervised and unsupervised modeling techniques, and their applications. Translation of model outputs to business policies and practices. Pre: Graduate standing.

Credit Hour(s): 2

Lecture Hour(s): 2

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

BIT 5404:

Decision Modeling & Business Analytics

Business decision modeling, including descriptive, predictive and prescriptive analytics. Linear and integer programming, distribution and network modeling, waiting line analysis, non-linear modeling, and multi-criteria decision making. Simulation for extending decision modeling to

scenarios involving uncertainty and risk. Software tools for problem analysis and solution. Translation of model outputs to business policies and practices. Illustrating applications in organizations of all types and in global environments. Pre: Graduate Standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

BIT 5414:

Operations Management in a Global Environment

Role of operations and supply chain management in modern organizations. Organizational value creation through product and process design and management, use of appropriate quality processes and metrics, location and layout of facilities, coordination of supply chain partners and processes, forecasting demand, managing inventory, and using systems and technology effectively, in production and service industries. Emphasis on global issues, quantitative techniques, and the use of technology. Pre: Graduate Standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

BIT 5424:

Bus Visualization Analytics

Principles and techniques for information visualization and reporting for business analytics. Covers principles of human perception and application of information visualization software for preparation, exploration, synthesis, interpretation, and presentation of business data to support decision making. Pre: Graduate Standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

BIT 5474:

Computer-based Decision Support Systems

This course explains the characteristics, use, and development of decision support systems (DSS) within the context of other business information systems. The process of designing and implementing

decision support systems in business is discussed from both theoretical and practical standpoints. Students will learn various ways of measuring the success of DSS implementation as well as the difficulties associated with all such measures. Students will learn to use common software tools to develop a simple DSS and will learn to use the Internet as a decision making and productivity tool. Pre: Graduate student standing or instructors consent.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

BIT 5484:

Cognitive Computing for Smart Service Systems

Modeling and design of smart services and service systems. Application of deep question-answer processes in subject matter domains for cognitive assistants. Integration of cognitive assistants into smart service systems. Service journey customization through context-adaptive cognitive assistants. Application of state-of-the-art cognitive computing resources towards building and training a cognitive computing system in a subject domain.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): BIT 5474

Corequisite(s):

BIT 5494:

International Operations and Information Technology

This course includes concepts and issues critical in the globalization of business operations and information technology. Topics covered include the organization of global operations, cultural and national comparisons, planning global operations, facilities location, product development, technology transfer, global communication links, transborder data flow, international information systems, and other emerging operations and information technology issues.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

BIT 5495:

Decision Support Systems Design and Implementation

Study of the design and implementation of decision support systems (DSS) using a visual environment. Topics will include methods for data access, modeling and computation in a visual language, graphical display of support material and report generation methodologies, object sharing between software components, and the deployment of support systems within distributed environments. Distributed DSS topics will include client server systems, common object model methodologies, and distribution in a web-based environment.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): BIT 5474 (UG) OR BIT 5474

Corequisite(s):

BIT 5524:

Introduction to Business Intelligence and Analytics

Overview of business intelligence and analytics technologies and their strategic use including defining/framing the business context for decisions, decision models, data issues, business intelligence, building analytics capability, cloud computing, making organizations smarter, and measuring the value of analytics. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

BIT 5534:

Applied Business Intelligence and Analytics

Development of business intelligence and analytics solutions and applications to various types of decision-making problems. Analytics software and techniques. Data preparation, data exploration and visualization, predictive analytics techniques, text analytics, spatial analytics.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): BIT 5524

Corequisite(s):

BIT 5564:

Healthcare Information Technology

39 Use of information technology in the health care industry. Topics

address electronic health records, patient informatics, evidence based medicine, electronic prescribing and telemedicine. The use of these technologies to improve patient health and medical systems operations.

Pre-requisite: Graduate Standing required

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ACIS 4515, CS 2604

Corequisite(s):

BIT 5574 (ACIS 5574):

Healthcare Data Management

Organization and management of data in the health care industry. Includes standards for electronic health records, healthcare enterprise systems architecture, health database design, existing database platforms, data integration from multiple sources, and database accessibility. Analysis of health-care-related organizations from the perspective of multiple user groups including patients, technicians, nurses, physicians, clinics, hospitals, and insurance companies.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): BIT 5564

Corequisite(s):

BIT 5594:

Web-Based Applications and Electronic Commerce

An examination of the concepts, technology, and applications of electronic commerce in business and society. Topics include the world wide web as a platform for electronic commerce; intranets; electronic data interchange; electronic banking and payment systems; implementing security technologies and policies, security and firewalls; software agents; and social, legal, corporate governance and international issues of electronic commerce.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): (ACIS 5514 (UG) OR BIT 5474 (UG)) OR (ACIS 5514 OR BIT 5474)

Corequisite(s):

BIT 5604:

Modeling Decision Making for Competitive Advantage

This course examines a number of topics in management science and

their applications in dealing with managerial problem solving. Decision theory and optimization techniques such as decision-trees, linear programming, integer programming, networks and others are studied, modeled and solved from a managerial and applied perspective.

Business and industry cases are used to demonstrate usefulness and effectiveness of the models constructed. Students use software to perform computational studies, obtain solutions, and analyze the results for problems and cases. Graduate standing required. Executive MBA and Professional MBA Students only.

Credit Hour(s): 2

Lecture Hour(s): 2

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

BIT 5624:

Program Management and Project Leadership

This course introduces the fundamentals of program and project management, beginning with project definition and culminating in the post-project review. Students will learn techniques, terms, and guidelines that are used to manage cost, schedules, risk, group dynamics, and technical aspects throughout the life cycle of a project.

Credit Hour(s): 1 TO 3

Lecture Hour(s): 1 TO 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

BIT 5644:

Management of Information for Business Decisions

This course illustrates a variety of statistical methods to collect and analyze data sets. Complex problems, both business and societal, are studied and analyzed for trends, patterns, relationships and other useful information. Statistical tools such as probability distributions, sampling, hypothesis testing, regression and times series analysis, simulation, and forecasting are studied from a practical and business perspective.

Business and industry cases are used to demonstrate the usefulness and effectiveness of the techniques used. Students use software to perform computational studies, obtain solutions, and analyze the results. Pre: Graduate standing in Executive MBA or Professional MBA program.

Credit Hour(s): 2

Lecture Hour(s): 2

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

BIT 5654:

Project Management

This course introduces the fundamentals of project management, beginning with project definition and culminating in the post-project review. Students will learn techniques, terms, and guidelines that are used to manage cost, schedules, risk, group dynamics, and technical aspects throughout the life cycle of a project. Graduate standing required; Executive or Professional MBA students only

Credit Hour(s): 2

Lecture Hour(s): 2

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

BIT 5664:

Managing the Global Supply Chain

This course provides the student with expertise in the planning and control of business processes within a firm and across its global supply chain. Emphasis is placed on applying IT and process analysis skills to improving the quality and productivity of business firms and their supply chain partners. Efficient methods for streamlining the flow of information, services and products across functions, enterprises, and global boundaries are studied. Issues in designing and managing a network of suppliers in a global environment are discussed. Pre: Graduate standing in Executive MBA or Professional MBA program.

Credit Hour(s): 2

Lecture Hour(s): 2

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

BIT 5724:

Managerial Statistics

Introduction to basic statistical (inference) tools necessary in managerial decision-making. Topics include, but are not limited to, descriptive statistics, elementary probability theory, sampling and sampling distributions, portfolio management, hypothesis testing, regression analysis, quality improvement, and Six Sigma concepts and methodology. Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

BIT 5894:

Final Examination

NONE

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

BIT 5954:

Study Abroad

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

BIT 5964:

Field Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

BIT 5974:

Independent Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Independent Study, VI

Instruction Type(s): Independent Study, VI

Prerequisite(s):

Corequisite(s):

BIT 5984:

Special Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

BIT 5994:

Research and Thesis

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research, Online Research

Instruction Type(s): Research, Online Research

Prerequisite(s):

Corequisite(s):

BIT 6324:

Design Science Seminar

Conceptual framework and research guidelines for analyzing and evaluating design science research. Selective, intensive coverage of topics related to creating and testing new and innovative information technology artifacts within the broader disciplines of information systems and operations management. Specific focus on research opportunities offered by social media analytics in design science research. Practical application of methods and techniques involving social media analytics in design science studies. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

BIT 6334:

Operations Management Seminar

Principles for analyzing and evaluating quantitative approaches to enterprise resource management (materials, labor, capacities, capital and information), in public, private, for-profit, and non-profit organizations. Production, Finance, human resources, and all forms of operations management. Advanced mathematical modeling of decisions for design, planning, and control. Analysis of research papers that involve theoretical development or rigorous application to the topics addressed in the course. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

BIT 6344:

Decision Analytics Seminar

Advanced study of analytic modeling techniques in support of decision making in a business context. Development and application of analytics to research problems in business management, transportation retailing, entertainment, government services, health care, and personal decisions. Emphasis on state-of-the-art approaches for descriptive, predictive, and prescriptive modeling. Evaluation of research papers that illustrate rigorous application and analysis of the topics covered in the course. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

BIT 6414:

Seminar in Information Technology

Advanced study of selected current topics in information technology emphasizing professional journal articles. Student research should lead to publishable paper. Course may be taken multiple times. Pre: restricted to graduate students in the Department of Business Information Technology.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

BIT 6984:

Special Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

BIT 7994:

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research, Online Research

Instruction Type(s): Research, Online Research

Prerequisite(s):

Corequisite(s):

BUSINESS, FINANCE

Vijay Singal, Head

Professors: Gregory Kadlec; Arthur Keown; Raman Kumar; Ruth Lytton; Sattar Mansi; George Morgan; Vijay Singal;

Associate Professors: Randall Billingsley; John Easterwood; Roger Edelen; Jin Xu;

Assistant Professors: Andrew MacKinlay; Bradley Paye; Ngoc Tran; Pengfei Ye;

Visiting Faculty: Nikolaos Artavanis; Roie Hauser; Frederick Hood;

Professor of Practice: Michael Kender;

R. B. Pamplin Professor of Finance: Gregory Kadlec;

R.V & A.F Oliver Professor of Investment Management: Raman Kumar;

Wells Fargo Professorship in Financial Risk Management: Sattar Mansi;

SunTrust Professor of Finance: George Morgan;

J. Gray Ferguson Professor of Finance: Vijay Singal;

R.B. Pamplin Professor of Finance: Arthur Keown;

Graduate Contact: zarabeth@vt.edu

Graduate Site: <http://www.finance.pamplin.vt.edu>

Graduate School: <http://graduateschool.vt.edu/>

The Department of Finance, Insurance and Business Law offers graduate studies leading to two advanced degrees: the Ph.D. and M.S. in Business (with specialization in Finance). The M.S. is a 30-hour non-thesis program designed for a limited number of highly qualified students who wish to undertake specialized training in finance. However, students are not always admitted to the M.S. program. The PhD program requires dissertation on an approved topic in finance and is designed to prepare students for academic careers in research-oriented schools of business. Accordingly, the program's primary focus is on research. Over the first two years in the program students develop their conceptual and empirical tool kits by taking a series of graduate level courses in Economics, Statistics, Econometrics and four semesters of doctoral seminars in Finance. Students are also required to write research papers after their first and second year in the program, in addition to the dissertation. They are also provided the opportunity to teach at least three courses during the program. Thus the program aims to prepare them for the research and teaching missions of their academic career. As a small program with an enrollment of two or three a year, the students get plenty of personal attention from our department faculty which is nationally recognized for its contribution to research. More information may be found on the Finance webpage at

<https://finance.pamplin.vt.edu/academics/phd-program.html>.

SPECIAL FACILITIES

The Finance department is located in Pamplin Hall with the main department office at 1016 Pamplin.

Finance Facilities Introduction

The Finance department is located in Pamplin Hall with the main department office at 1016 Pamplin.

DEGREES OFFERED

MS Degree

Offered In (Blacksburg)

TOEFL

Paper: (600.0)

Computer: (250.0)

iBT: (80.0)

GMAT

The M.S. is a 30-hour non-thesis program designed for a limited number of highly qualified students who wish to undertake specialized training in finance. However, students are not always admitted to the M.S. program.

PhD Degree

Offered In (Blacksburg)

TOEFL

Paper: (600.0)

Computer: (250.0)

iBT: (80.0)

GMAT

: Total (600.0)

Students admitted into the program typically have a master's degree, competitive GMAT scores, strong transcripts and letters of recommendation. Financial aid is provided for four years conditional on satisfactory academic progress. Additionally, the department provides a "Professional Development Fund" to each student to help defray costs of conference travel, journal submission fees, etc. Fifth year funding is available based on a case by case basis. During the first two years students are required to take about 40 hours of course work including nine 3-credit courses in microeconomics, macroeconomics, statistics and econometrics, and four 3-credit doctoral seminars in finance --- two each in Corporate Finance and Investments. Additionally, the students sign up for at least 50 hours of Research and Dissertation credits over the four years, adding up to at least 90 credit hours required to graduate from the doctoral program. In addition to the course work the students are required to successfully present their first and second year research papers to the faculty to better prepare them for their upcoming dissertation. The submission and presentation of the second year paper is one of two key events in the program. The other key event is the dissertation defense.

GRADUATE COURSES (FIN)

FIN 5024:

Principles of Finance

Explores the basic concepts underlying the finance function, relevant to finance and non-finance majors. It provides an understanding of the firm's decision-making framework in the context of the economic environment (financial markets) in which the decisions are made. The specific topics covered, at a basic level, include investment decision under uncertainty, valuation, risk and return, market efficiency, portfolio theory, asset pricing, cost of capital, capital investment decisions, and futures and options markets.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): BIT 5724, FIN 5084, ACIS 5104

Corequisite(s):

FIN 5084:

Analytical Framework for Business Managers

The course provides an analytical coverage of the concepts and principles that affect and govern a firm's relationships and interactions with its customers, suppliers (of goods, materials, services, and funds), competitors, employees, other organizations and the regulatory environment. The course is designed specifically for first semester MBA students and the coverage is from the perspective of a business manager. Topics covered include demand and supply analysis, individual choice, pricing strategies, market structure, monetary policy, and government regulation. Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

FIN 5104:

Corporate Finance

Provides a broad coverage of the major policy making areas of a corporation. The course covers topics in capital investment policy, financing and capital structure policies, dividend policy, financial statement analysis, financial forecasting, and the basics of working capital management.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): FIN 5024

Corequisite(s):

FIN 5114:

Interest Rates and Fixed Income Securities

Analysis of the macroeconomic environment of interest rate determination and monetary policy. Description and analysis of several classes of fixed income securities. Measurement and management of interest rate risk. Introduction to arbitrage-free term structure modeling and applications to the pricing and hedging of debt securities.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): FIN 5024

Corequisite(s):

FIN 5124:

Investment Analysis and Portfolio Management

Examines the role and functioning of securities markets. Specific topics include the equity market, fixed-income securities market, and mutual funds. The course presents portfolio and capital market theory, the efficient markets hypothesis, institutional organization, and security valuation techniques.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): FIN 5024

Corequisite(s):

FIN 5174:

Corporate Financial Risk Management

Derivative securities such as options, futures, forwards and swaps, and their payoffs and profits. Use of binomial and Black-Scholes models for pricing options. Relationship between spot and forward prices. Use of real options in capital budgeting. Identification of domestic and global risk management problems of corporations. Application of derivative contracts to manage corporate risk.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): FIN 5024

Corequisite(s):

Corequisite(s):

FIN 5184:

Currencies and Global Finance

Explores the international economic environment, including analyses of exchange rates, international monetary systems, contemporary currency regimes, and current financial crises. Examines a firm's exposure to various kinds of exchange risks and the methods and financial instruments used to manage those risks. Introduces global opportunities open to firms for raising capital, foreign investment in financial assets, and managing currency and interest rate risk.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): FIN 5024

Corequisite(s):

FIN 5194:

Commercial Law and Professional Liability

Study of the Uniform Commercial Code, including negotiable instruments, sale of goods, secured transactions and documents of title. Debtor-creditor relations, special topics in business organization law, and the law of professional liability. Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): FIN 3055 (UG) OR FIN 3054 (UG) OR FIN 3074 (UG)

Corequisite(s):

FIN 5284:

Free Markets, Individual Freedom, and Social Welfare

Expose students to the various viewpoints on the role that free markets can and do play in promoting individual freedoms and enhancing social welfare. This course will explore the strengths and weaknesses of capitalism by critically evaluating the relationship between the economic efficiency achieved by capitalism and the attainment of social welfare objectives. The course will also examine the economic and social welfare implications of current issues that could include globalization, price controls, income inequality, outsourcing, corporate pricing power through monopoly/oligopoly, and government regulation of the economy. Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

FIN 5604:

Financial and Economic Environment of Business

Provide an understanding of the principles that affect a firm's interactions with its customers, suppliers, competitors, employees, and other organizations, and the roles of monetary and fiscal policies in the overall economic environment. Study the basic principles and concepts underlying the finance function. Topics covered include demand and supply analysis, individual choice, pricing strategies, market structure, monetary and fiscal policies, and the role of the Federal Reserve in managing growth, employment, and inflation. Graduate standing required. Executive MBA and Professional MBA students only.

Credit Hour(s): 2

Lecture Hour(s): 2

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

FIN 5614:

Financial Modeling and Corporate Finance

Provides coverage of the major financial decisions facing a corporate manager in a modeling framework. The specific topics covered are analysis of financial statements, financial planning, cost of capital and capital budgeting, capital structure, working capital management, dividend policy, and international financial management. Executive MBA students only.

Credit Hour(s): 2

Lecture Hour(s): 2

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

FIN 5654:

Principles of Financial Management

Provide an understanding of the basic principles and concepts underlying the finance function, and the analytical tools for making financial decisions. The specific topics covered are Goals of a Corporate Firm and Agency Problem, Cash Flow Estimation and Financial Statement Analysis, Financial Assets and Markets, Time Value of Money, Risk and Return, Diversification and Capital Asset Pricing Model, Valuation of Stocks and Bonds, and Market Efficiency. Executive MBA and Professional MBA students only.

Credit Hour(s): 2

Lecture Hour(s): 2

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): FIN 5604

Corequisite(s):

FIN 5664:

Corporate Finance

Explores value creation through capital investment and capital structure choices. Provides an understanding of the impact of capital investment and capital structure policies on the value of a corporation. Includes a theoretical component and a strong applied component with cases and projects. Executive MBA and Professional MBA students only.

Credit Hour(s): 2

Lecture Hour(s): 2

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): FIN 5654

Corequisite(s):

FIN 5674:

Investments and Portfolio Management

Risk, return and portfolio theory, knowledge of equity and debt markets, derivatives, and management of investment portfolios. Introduction to equity and bond valuation, mutual funds, portfolio analysis, market efficiency, options, and futures. Executive MBA and Professional MBA students only.

Credit Hour(s): 2

Lecture Hour(s): 2

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): FIN 5654

Corequisite(s):

FIN 5734:

Legal and Ethical Issues in Innovation and Technology

Intensive exploration of legal and ethical issues that affect the operation of business in the high technology, networked, environment. Studies public and private regulation of business, emphasizing innovation and the networked environment. Explores the interrelationship of ethics and law, the duties of directors and managers, and decision-making under uncertain regulatory parameters, especially in evolving businesses.

Included within these areas are: participating in the regulatory process, intellectual property, ethical frameworks, privacy and security, and international perspectives. Pre: Graduate standing required. Professional

MBA students only.

Credit Hour(s): 2

Lecture Hour(s): 2

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

FIN 5744:

Current Topics in Corporate Governance

Current issues and trends in corporate governance. Topics include overview of the corporation, stakeholder versus shareholder, board of directors, executive compensation, ownership structure, committee assignments, regulatory and legal environment, and firm performance. Graduate standing in the Professional MBA program required.

Credit Hour(s): 2

Lecture Hour(s): 2

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

FIN 5784:

Global Finance

International economic environment, currency regimes, and currency crises; analysis of foreign exchange rates. Firms exposure to exchange risk and methods for managing risk including competitive and transaction exposure. Global opportunities to raise capital and foreign investment vehicles. Professional MBA students only.

Credit Hour(s): 2

Lecture Hour(s): 2

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): FIN 5654

Corequisite(s):

FIN 5894:

Final Examination

NONE

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

FIN 5954:

Study Abroad

NONE

Lecture Hour(s): 1 TO 6
Instruction Type(s): Lecture, Online Lecture
Instruction Type(s): Lecture, Online Lecture
Prerequisite(s):
Corequisite(s):

FIN 5974:

Independent Study

NONE
Credit Hour(s): 1 TO 19
Lecture Hour(s): 1 TO 19
Instruction Type(s): Independent Study, VI
Instruction Type(s): Independent Study, VI
Prerequisite(s):
Corequisite(s):

FIN 5984:

Special Study

NONE
Credit Hour(s): 1 TO 19
Lecture Hour(s): 1 TO 19
Instruction Type(s): Lecture, Online Lecture
Instruction Type(s): Lecture, Online Lecture
Prerequisite(s):
Corequisite(s):

FIN 5994:

Research and Thesis

NONE
Credit Hour(s): 1 TO 19
Lecture Hour(s):
Instruction Type(s): Research, Online Research
Instruction Type(s): Research, Online Research
Prerequisite(s):
Corequisite(s):

FIN 6104:

Financial Research Methods

Integration of econometric methodology (including regression) and inference with research in finance, financial accounting and other quantitative business research issues/areas. Introduction to the data used in financial research. Discussion of research papers which incorporate rigorous applications of the topics covered in the course. Topics covered include event studies, estimation of systematic risk (beta) of stocks, cross-section of expected stock returns, and common econometric problems such as heteroscedasticity, autocorrelation and multicollinearity in business settings and their resolution. Pre: Graduate

Standing
Credit Hour(s): 3
Lecture Hour(s): 3
Instruction Type(s): Lecture, Online Lecture
Instruction Type(s): Lecture, Online Lecture
Prerequisite(s):
Corequisite(s):

FIN 6115:

Corporate Finance

Analysis of financial decisions in the corporate firm under uncertainty and in the presence of agency costs, information asymmetries, incomplete markets, and taxation.
Credit Hour(s): 3
Lecture Hour(s): 3
Instruction Type(s): Lecture, Online Lecture
Instruction Type(s): Lecture, Online Lecture
Prerequisite(s): FIN 6004
Corequisite(s):

FIN 6116:

Corporate Finance

Analysis of financial decisions in the corporate firm under uncertainty and in the presence of agency costs, information asymmetries, incomplete markets, and taxation.
Credit Hour(s): 3
Lecture Hour(s): 3
Instruction Type(s): Lecture, Online Lecture
Instruction Type(s): Lecture, Online Lecture
Prerequisite(s): FIN 6004
Corequisite(s):

FIN 6125:

Investments

Advanced treatment of equity, debt, and speculative markets. Topics include security return distributions, market efficiency, mean-variance portfolio theory, capital asset pricing, arbitrage pricing, option pricing models, and futures markets. Theory and empirical evidence are examined.
Credit Hour(s): 3
Lecture Hour(s): 3
Instruction Type(s): Lecture, Online Lecture
Instruction Type(s): Lecture, Online Lecture
Prerequisite(s): FIN 6004
Corequisite(s):

Investments

Advanced treatment of equity, debt, and speculative markets. Topics include security return distributions, market efficiency, mean-variance portfolio theory, capital asset pricing, arbitrage pricing, option pricing models, and futures markets. Theory and empirical evidence are examined.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): FIN 6004

Corequisite(s):

FIN 6984:

Special Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

FIN 7994:

Research and Dissertation

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research, Online Research

Instruction Type(s): Research, Online Research

Prerequisite(s):

Corequisite(s):

BUSINESS, HOSPITALITY AND TOURISM MANAGEMENT

Nancy McGehee, Head

Professors: Mahmood Khan; Nancy McGehee; Juan Nicolau Gonzalbez; Richard Perdue;

Associate Professors: Manisha Singal; Zheng Xiang;

Assistant Professors: Eojina Kim; Florian Zach;

Visiting Faculty: Kristin Lamoureux;

R.B. Pamplin Professor of Hospitality and Tourism Management: Richard Perdue;

J. Willard and Alice S. Marriott Professor of Revenue Management: Juan

Nicolau Gonzalbez;

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HTM Departmental Website: <http://www.htm.pamplin.vt.edu/graduate/index.html>

The Virginia Tech Hospitality and Tourism Management (HTM) graduate programs are consistent with the mission of a comprehensive research university; our program emphasizes developing student ability to generate new knowledge through research and to apply that knowledge to the challenges and problems of hospitality and tourism businesses. HTM is one of six departments in the Pamplin College of Business. Our vision, which permeates throughout our graduate program, is to build on a legacy of teaching and research excellence and to create global leaders in the business of hospitality and tourism management. We offer two graduate degrees: Masters of Science in Business Administration (MSBA) with a concentration in Hospitality and Tourism Management, and a Ph.D. in Business with a Concentration in Hospitality and Tourism Management. The MSBA is offered primarily at our National Capital Region Campus in Falls Church Virginia but with availability via online capabilities on our Blacksburg campus. Three graduate certificates are also available at our National Capital Region Campus in revenue management and data analytics, international strategy, and entrepreneurship. For more information, go to the certificate tab in the graduate catalog. The Ph.D. is offered exclusively at the Virginia Tech campus in Blacksburg. Our graduate program is widely recognized as one of the premier programs of its kind in the world. Graduates are prepared for challenging Hospitality and Tourism Management careers in academic and/or industry positions. Two principles permeate our graduate programs. First, our graduate programs focus on the application of theories and methodologies from a variety of disciplines to the critical challenges and problems of hospitality and tourism management businesses; the department provides extensive opportunities for graduate students to partner with faculty to conduct research on significant industry problems. Second, the program is customized to the student's interests; degree candidates and their advisory committees plan individual graduate programs pursuant to the student's career goals and degree requirements. For MSBA graduate students, the program provides an opportunity for growth as a student and as a career-directed individual. The goal is to provide advanced knowledge and tools to middle management personnel, consultants and researchers in the hospitality and tourism industry. This goal is accomplished by providing a stimulating environment that encourages seeking knowledge and applying it to the needs of the industry. Fulfillment of the goal occurs as a result of considerable interface and focus, in the classroom and out, with industry and educational leaders on issues of immediate and long-term importance to the industry. The degree includes opportunities in three primary areas of specialization: revenue management and data analytics, international strategy, and entrepreneurship. At the Ph.D. level, the program emphasizes the research applications of business concepts and strategies to hospitality and tourism management. The goal of the Ph.D. program is to develop the next generation of faculty for Hospitality and Tourism Management Business programs at major research universities throughout the world. We accomplish this goal by producing doctoral graduates who have both conceptual and methodological knowledge and significant research experience in the applications of that knowledge during their Ph.D. program. Students develop the knowledge, skills and research abilities

to become successful scholars by engaging in close and collegial research collaborations with a faculty comprised of internationally renowned scholars, journal editors, and professional leaders.

SPECIAL FACILITIES

Our graduate programs are offered on two campuses. The Masters of Science in Business Administration and the associated Certificate Programs are offered primarily at our National Capital Region Campus in Falls Church Virginia but with availability via online capabilities on our Blacksburg campus. As a professional degree, this location in the nation's leading hospitality hub provides easy access to many of the world's major hospitality corporations. The Ph.D. in Business is offered exclusively on the main Virginia Tech campus in Blacksburg, providing easy access to our research library, research and statistical support systems, and our research community of leading scholars both in the Pamplin College of Business and in other departments and colleges across campus. On the Blacksburg campus, the Department of Hospitality and Tourism Management occupies the third floor of Wallace Hall. The Ph.D. student facilities include private carrels and a dedicated computer lab with access to a full range of office, graphical, scientific, and statistical software. All Ph.D. classes are taught in a dedicated classroom with comprehensive technological equipment and software. The Department partners with the Inn at Virginia Tech, the Virginia Tech Dining Service, and the local and regional hospitality and tourism industry to provide research and internship opportunities.

University Research Facilities

Virginia Tech is a comprehensive research university with world class technology, computing, and library resources.

DEGREES OFFERED

PhD Degree

Offered In (Blacksburg)

GMAT

GRE

General: Verbal, Quantitative, Analytical

TOEFL

Paper: (577.0)

iBT: (90.0)

Virginia Tech's Hospitality and Tourism Management Ph.D. in Business emphasizes the research applications of business concepts and strategies to hospitality and tourism management. The goal of our program is to develop the next generation of faculty for Hospitality and Tourism Management Business programs at major research universities throughout the world. We accomplish this goal by producing doctoral graduates who have both conceptual and methodological knowledge and significant research experience in the applications of that knowledge during their Ph.D. program. Students develop the knowledge, skills and research abilities to become successful scholars by engaging in close and collegial research collaborations with a faculty comprised of internationally renowned scholars, journal editors, and professional leaders. More specifically, our curriculum emphasizes (1) the understanding of business theories and practices in hospitality and tourism management and (2) the conceptual skills and understanding of research design, measurement, and statistical analyses necessary to be

effective and productive researchers. The faculty has developed the doctoral program to provide challenging research and learning experiences for students seeking the skills to become leading researchers. The key ingredients to the program's success are excellent students, a dynamic, research-oriented faculty who publish regularly in top-tier journals, and research collaboration between students and faculty. The specific curriculum and research program is customized to the individual student's interests; each student works with an advisory committee to develop a program of study and a research dissertation focusing on her / his specific areas of interest. Degree Requirements (66 Credits plus the MS or MBA) Core Requirements (15 credits / 12 graded credits, see note 1) * HTM 5944 Graduate Seminar (taken each semester in residence with 3 credits toward the degree) * 12 credits of coursework in research methodology, ethics, and data analysis taken at the Ph.D. level at Virginia Tech HTM Requirements (6 credits / 6 graded credits) * HTM 6434: Theory Development for Hospitality & Service Management (3 credits) * HTM 6464: Research Foundations in Hospitality and Tourism Management (3 credits) Specialization/Major Area (15 credits / at least 9 credits must be graded) * At least 3 credits need to be at the HTM 6000 level * Remaining credits (12) can be either within or outside HTM, and can be at the 5000 or 6000 level. * Students are encouraged to include at least one section of HTM 6974 Independent Study, whereby the finished product is a manuscript to be submitted to a top-tier academic research journal. Students are also encouraged to take GRAD 5114, Contemporary Pedagogy, if they and their committee feel this would assist them with improving their teaching skills. Dissertation (30 credits) Total Credits – 66 Credits Notes: 1) Depending on the student's specific research interests, the Pamplin College of Business offers a series of behavioral, financial, data analytic, and econometric methodology courses. Additionally, students may substitute other Ph.D. level methodology courses from elsewhere at Virginia Tech. All substitutions must be approved by the student's primary advisor and the HTM Department Head. 2) A minimum of 9 credits of coursework are required each semester of the first two years of the program. Students receiving either GTA or GRA support are required to take 12 credits of coursework each semester they are funded. 3) Courses should be taken in consultation with the committee and approval of the Head of the Department. 4) Courses cannot be counted twice under any of the above mentioned categories. 5) No more than 9 hours can be taken as independent study courses. 6) Consult graduate catalog for the number of courses that can be transferred. Ph.D. Degree Progression and Requirements Advisory Committee Students selected for admission to the Ph.D. program are accepted by a faculty member who will be their major professor. This selection is based primarily on the potential of a match between the professor's expertise and the student's interest as expressed on the application for the program. An Advisory Committee consisting of the major professor and at least three other members will be recommended by the student and his / her major professor to the Department Head to be recommended to the Graduate School. This committee advises the student in planning a program of study and in other degree requirements. It also serves as the examining committee for the preliminary and final examinations. A typical committee consists of a minimum of three faculty (including the major professor/chair) from the Department of Hospitality and Tourism Management. It is expected, but not required that the committee include at least one faculty member from outside the Department reflecting the student's cognate area. Preference is given to on-campus faculty. The makeup of the advisory committee may be different for the preliminary exams and the dissertation. The student should consult with his/her major professor in determining the makeup of the advisory committee. Additional information about the advisory committee can be found in the Graduate School catalog. Program of Study A Program of Study refers to the plan of course work

and any other related experiences that prepare the student for successful completion of the preliminary exams and dissertation defense. A program of study meeting all department requirements should be submitted to the Graduate School prior to completing the third semester in residence beyond the Masters degree at this University. The program of study must be approved and endorsed by the student's advisory committee, the Department Head, and the Graduate School.

Qualifying Exam The HTM Qualifying Exam for first year Ph.D. students is comprised of a research project completed during the spring and summer of their first year. **Research Proposal:** During the spring semester, students will work with their primary advisor to develop and submit to the HTM Graduate Coordinator by April 1 a five to ten page research proposal that includes: Applied and theoretical justification for the research study (including the study's managerial contribution and theoretical foundations which are supported by a summary of the literature) The specific research questions, problem, and/or hypotheses Research methodology A detailed timeline for the research project As this work will commonly extend beyond the end of the summer, the proposal should include a statement articulating the deliverables which will be provided by September 1 as part of the preliminary research report The contribution of the proposed research to the student's Ph.D. program of study Anticipated target journal Prior to submission, this proposal must be approved by the student's committee chair.

Preliminary Research Report (due September 1) With the guidance of their Ph.D. committee chair, students will develop and submit to the HTM Graduate Coordinator a report of work completed during the summer. This report should coincide with the approved list of deliverables provided in the proposal. Deviations from the approved list of deliverables would be considered only as a rare exception and must be explained and justified. Prior to submission, this report will be approved by the student's committee chair.

Final Research Report Draft Manuscript (due by December 31) Under the guidance of their Ph.D. committee chair, students will develop and submit to the HTM Graduate Coordinator a final research report draft manuscript being prepared for journal submission, reporting on the approved summer research project. While it is anticipated that this report may not yet be completed, it should include, at a minimum, a well-articulated introduction, a substantive review of the literature, a detailed description of the research methodology, and preliminary results. Prior to submission, this report must be approved by the student's committee chair.

During the fall semester, students will be required to present the research to HTM 5944 Graduate Seminar. **Preliminary Examination** This examination is designed to determine the candidate's ability to progress into the dissertation phase. The written portion of the examination is to be completed within 6 months of completion of coursework. The oral examination phase requires that an examination card be obtained. The graduate student is responsible for the completion and submission of all paperwork required from the Graduate School at least two weeks in advance of the exam date. The examination is given in two parts: 1. **Written Examination** 2. **Oral Examination** – scheduled within 30 days of successful completion of the written examination. **Student Qualification Requirements** Students sitting for all preliminary exam components, i.e. written and oral examination parts, must have completed the following; 1. **Approval of the Student's Chair and Committee members** 2. They must have fulfilled all requirements for taking their preliminary examination as stipulated by the Graduate School (see Graduate Catalog). 3. They must have an approved plan of study on file with the Graduate School. **Written Preliminary Examination - Specialization (Major) Area** The preliminary exam, oral and/or written, is conducted by the student's advisory committee. It is comprehensive in nature and is intended to test a student's ability to integrate, synthesize, and apply concepts, facts, and techniques in solving new and complex problems associated with hospitality and

tourism management. The student may be tested on any aspect of their plan of study. It is recommended that the student meet with his/her advisory committee prior to preparing for the exam to discuss the nature of the exam, the format, and the evaluation procedures that is the best fit. **Dissertation Candidates for the Ph.D.** are required to carry out original research which will add to the present body of knowledge in the field of hospitality and tourism management. Students are required to defend their proposal for their dissertation research to their dissertation committee. Prior to this defense they must present their proposal in the HTM 5944 Graduate Seminar. The purpose of this exercise is to provide students with the opportunity to get feedback from peers and faculty before actually defending the proposal to his/her committee. Guidelines for this seminar are available in the HTM Department. The department supports both traditional and article-style formats for dissertations. See departmental policy for process. **Final Examination** This oral examination is primarily a defense of the dissertation, although the examining committee may test the candidate on any material relevant to the field of study. The examination is scheduled through the Graduate School in the same manner as the written preliminary examination. A final presentation of the dissertation in Graduate Seminar is also required. Graduate School requirements must be met for submission of dissertation. Refer to the Virginia Tech Graduate School Policies and Procedures for further information.

MS Degree

Offered In (National Capital Region)

The MS in Business Administration (MSBA) with a concentration in Hospitality and Tourism Management is in the Washington DC metro area, the nations' hub for hospitality business; it is offered exclusively at the Virginia Tech National Capital Region Campus in Falls Church VA. The MSBA is a professional degree designed to either help students advance their professional career in HTM or as an important step to pursuing a Ph.D. and a subsequent academic career. The MSBA focuses on three areas: Hospitality and Tourism Business Analytics and Revenue Management, International Hospitality and Tourism Strategy, and Entrepreneurship in Hospitality and Tourism Management. The MSBA program is designed to allow students to pursue specializations in each of these focal areas. Many of the MSBA courses are taught by industry professionals with a strong focus on professional practice and case studies. The student's plan of study is designed and approved in conjunction with a graduate advisory committee comprised of a chair and a minimum of two graduate faculty members. On admission into the graduate program, an initial advisor is assigned by the Graduate Program Director. The student can change this advisor after s/he has the opportunity to better know the faculty and articulate her/his interests. The following reflects the general framework of the MSBA plans of study.

Master of Science in Business Administration: Hospitality and Tourism Management I. Business Core Course: (15 hours of coursework)

BIT 5724 Managerial Statistics	ACIS 5104
Fundamentals of Accounting	FIN 5024 Principles of Finance
MGT 5314 Dynamics of Organization Behavior	MKTG 5104 Marketing Policy and Strategy II.

HTM Concentration: (15 Hours of coursework selected from the following areas.) HTM courses should constitute at least 50% (three courses) of the concentration hours. Students are encouraged to complete at least one of the specializations. Students may opt to take additional hours to complete all three specializations, or they can take additional hours to complete complimentary graduate certifications. For more information, go to the Certificates section of the Graduate catalog. **Hospitality and Tourism Business Analytics and Revenue Management Specialization** Offered during the Summer, 9 hours (100% online)

Required: HTM 5564 Information Technology and Business Analytics in Hospitality and Tourism Management HTM 5574 Revenue Management for Hospitality Services Choose a third course from either MGT or BIT :MGT 5804 Strategic Leadership in Technology-based OrganizationsBIT 5594 Web Applications and E-Commerce International Hospitality and Tourism Strategy SpecializationOffered during the Fall semester, 9 hours Required: HTM 5534 Strategic Management and Competitive Strategy in the Hospitality Industry HTM 5024 International Service Management Choose a third course from the following: MGT 5784 International ManagementMGT 5794 Strategic ManagementMKTG 5704 International Marketing Strategy Entrepreneurship in Hospitality and Tourism Management SpecializationOffered during the Spring semester, 9 hours Required: MGT 5814 Entrepreneurial Leadership Choose two courses from the following: HTM 5424 Human Resource ManagementHTM 5464 Franchising in Hospitality Management HTM 5444 Financial Management in the Hospitality Service Industries TOTAL HOURS REQUIRED FOR M.S.B.A. DEGREE: 30 HOURSTime to completion: 12-15 months

GRADUATE COURSES (HTM)

HTM 5024:

International Service Management

Overview of the contemporary issues in the international business environment facing multinational service firms in the hospitality industry.

These issues include such topics as: global strategy formulation, and implementation; technology challenges; diversity in customers and employees; political and legal concerns; and effective organizational structures for long term survival.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

HTM 5424:

Human Resource Management

This course focuses upon the attainment and retainment of employees within the hospitality industry. Topics include the processes, practices and legal considerations involved in the employment of people in hospitality organizations.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): MGT 3334

Corequisite(s):

HTM 5444:

Financial Management in the Hospitality Service Industries

Fundamentals of financial management as applied to hotel, restaurants, institutions and similar service organizations.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): FIN 3104

Corequisite(s):

HTM 5454:

Hospitality and Tourism Marketing Strategy and Policy

Examination of the role of marketing within the strategic planning of hospitality service organizations.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): MKTG 3104

Corequisite(s):

HTM 5464:

Franchising in Hospitality Management

Role of franchising in hospitality management. Contemporary issues related to franchising in different segments of hospitality industry, including franchise concept development, franchisor-franchisee relationship, franchise agreements, operational problems, and international franchising.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

HTM 5514:

Contemporary Problems in the Hospitality Industry

Consideration and analysis of relevant industry problems and issues facing management personnel in the hospitality industries. Computer literacy required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

HTM 5534:**Strategic Management and Competitive Strategy in the Hospitality Industries**

To enable students to develop a comprehensive understanding of the concepts of strategic management and competitive strategy as applied to the hospitality industries.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): HTM 4534

Corequisite(s):

HTM 5544:**Research Methods for Hospitality Applications**

The use of business research methods in the scientific investigation of hospitality related problems. The foundations of research, research design, data collection techniques, sampling issues, statistical techniques and the analysis and reporting of data will be studied.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): STAT 5634

Corequisite(s):

HTM 5554:**Qualitative Research Methods in Business**

This course focuses on the key components of qualitative methodology for research applications in business. The course introduces students to the basics of qualitative research in the business context as well as the ontological and epistemological foundations of qualitative research.

Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

HTM 5564:**Information Technology and Business Analytics in Hospitality and Tourism**

Theoretical foundation of IT applications in hospitality and tourism.

Widely used information systems in operation, management, and e-business in HTM. Web marketing and distribution practices. Emerging analytics tools for business intelligence and strategic decision making.

Impacts of IT on organizations and the industry as a whole. Pre:

Graduate Standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

HTM 5574:**Revenue Management for Hospitality Services**

Dynamic forecasting of supply and demand, customer relationship management, services production, pricing, promotion, and distribution. Implications for human resources and information systems management.

Application and integration of revenue and customer centric management theory. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

HTM 5614:**Current Issues in Travel and Tourism Management**

Current issues in the management of travel and tourism services. Environmental trends, planning and development, policy formulation, social and economic impact, and marketing of travel and tourism.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

HTM 5904:**Project and Report**

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research, Online Research

Instruction Type(s): Research, Online Research

Prerequisite(s):

Corequisite(s):

HTM 5944:

Presentation and critical discussion of current literature and major topics in hospitality and tourism management. The seminar provides a forum for the discussion of research and research problems in hospitality and tourism management and the presentation of research by graduate students. Provides students an opportunity to prepare and present current work related to their thesis and dissertation activities. May be repeated.

Credit Hour(s): 1

Lecture Hour(s): 1

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

HTM 5954:

Study Abroad

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

HTM 5964:

Field Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

HTM 5974:

Independent Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Independent Study, VI

Instruction Type(s): Independent Study, VI

Prerequisite(s):

Corequisite(s):

HTM 5984:

Special Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

HTM 5994:

Research and Thesis

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research, Online Research

Instruction Type(s): Research, Online Research

Prerequisite(s):

Corequisite(s):

HTM 6414:

The Concept of Service in the Hospitality Service Industries

Seminar in the concept of service and its management.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): HTM 5514

Corequisite(s):

HTM 6424:

Human Resources Management in the Service Industry

Examination of research and writings in the area of human resources management in service industries. Issues and opportunities in human resources management distinctive to hospitality service organizations.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): HTM 5424 OR MGT 5704

Corequisite(s):

HTM 6434:

Theory Development for Hospitality and Service Management

Seminar in theory construction in the areas of hospitality, tourism and service. Emphasis on the identification of relevant interdisciplinary paradigms and theory and the evaluation of social science research. Six graduate credits of hospitality and tourism courses required. Alternate years.

53 Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

HTM 6444:

Advanced Quantitative Methods for Hospitality Applications

Methodologies and techniques for analysis, reporting, and critiquing hospitality issues using advanced concepts and quantitative methods in the scientific investigation of problems related to hospitality.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): STAT 6634

Corequisite(s):

HTM 6454:

Hospitality Marketing Research Problems

Research designs and methodologies for the solution of hospitality industry marketing problems. Analysis and interpretation of marketing research studies.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): HTM 5454, STAT 5634

Corequisite(s):

HTM 6464:

Research Foundations in Hospitality and Tourism Management

Advanced survey of classical and current literature in hospitality and tourism management. Tools to assess research questions, opportunities, and limitations of the research.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): HTM 5544

Corequisite(s):

HTM 6524:

Seminar in Tourism Management Research

Intensive exposure to conceptual and methodological areas of research in tourism management. Design and implementation of original tourism research. Examines key areas of tourism management research,

including impact monitoring and measurement, destination development and management, forms of tourism activity, destination competitiveness and sustainability, tourism information systems and the tourist experience and behavior. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

HTM 6534:

Advanced Seminar in Strategic Management in the Hospitality Industry

This seminar is designed to provide an in depth exploration of the literature and research which has been developing in the context of the hospitality and tourism industry, specifically as it applies to the hotel, restaurant, and tourism sectors. Specific methodological approaches encountered in an industry specific environment will be identified and evaluated. The current state of theory development will be assessed and key issues relevant to further theory building will be explored. The course will be in a seminar format where students will be expected to develop a comprehensive and in-depth understanding of the body of knowledge relative to strategy in the hospitality and tourism industry. Must have the prerequisite or equivalent.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): HTM 5534

Corequisite(s):

HTM 6974:

Independent Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Independent Study, VI

Instruction Type(s): Independent Study, VI

Prerequisite(s):

Corequisite(s):

HTM 6984:

Special Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

HTM 7994:

Research and Dissertation

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research, Online Research

Instruction Type(s): Research, Online Research

Prerequisite(s):

Corequisite(s):

BUSINESS, MANAGEMENT

Devi Gnyawali, Head

Professors: Devi Gnyawali; Steven Markham;

Associate Professors: Jeffrey Arthur; Daniel Beal; William Becker; Donald

Hatfield; Karen Schnatterly; David Townsend; Anna Ward Bartlett; Ryan

Zimmerman;

Assistant Professors: Kiran Awate; Richard Hunt; Ayenda Kemp; Pankaj Kumar;

Maximilian Stallkamp; Phillip Thompson;

Pamplin Professor: Devi Gnyawali;

Digges Professor: Steven Markham;

Assistant Professor of Practice: David Bluey; Dirk Buengel; Elizabeth Jamison;

Ronnie Poff; William Schaudt;

Associate Professor of Practice: Kimberly Carlson;

Collegiate Associate Professors: Chien-Chi Tseng;

Collegiate Assistant Professors: Joseph Simpson;

Graduate Program: segiles@vt.edu

Graduate Program Director: rickhunt@vt.edu

Graduate Site: <http://management.pamplin.vt.edu/Academics/phd.html>

The Ph.D. program in Business Administration with a major in Management in the Pamplin College of Business is dedicated to preparing the next generation of research faculty at top academic institutions. The faculty of the Department of Management, who are highly respected both nationally and internationally, are committed to Ph.D. mentoring. That commitment is shown in a vibrant curriculum and an apprenticeship style that provides students opportunities to work closely with faculty. Our recent revision in the Ph.D. program has placed further emphasis on developing students' research skills and enabling students to develop papers for top-tier journals so that they are better prepared for faculty careers at research universities. Our approach to doctoral education is unique. We emphasize preparation of students in

ways that allow them to understand and address the whole organization from the study of individuals and groups within organizations to how they operate strategically in the larger business environment. Our program allows students to develop the knowledge and skills necessary to address the critical and complex questions faced by organizations today: those that require expertise that cuts across the boundaries of current organizational research disciplines. One of the core strengths of our program is the possibility for students to integrate micro and macro research literatures in order to examine phenomena of research interest. Our curriculum emphasizes a solid foundation in strategic management, organization theory, organizational behavior, human resources management, and ethics and social responsibility. Students first develop a firm understanding of management broadly, and then specialize in any of these areas based on their research interests and collaborations with faculty. In addition, students acquire and develop skills in research design, measurement, and statistical analysis that will allow them to be effective, independent researchers for their academic careers. Our doctoral students engage in close and collegial research collaboration with our faculty who are highly respected nationally and internationally based on their research excellence. These student-faculty research collaborations continue years after the students' graduation from our program. Our faculty has a strong commitment to teaching and Ph.D. mentoring. That commitment is shown in a vibrant curriculum and steady increases in the productivity of our graduate students. We view a doctoral education as the foundation for lifelong learning. We develop excellence in our students so that they can make significant scholarly contributions throughout their careers.

SPECIAL FACILITIES

DEGREES OFFERED

PhD Degree

Offered In (Blacksburg)

TOEFL

MGT TOEFL: Paper (550.0), Computer-based (233.0), Internet-based test: at least 80, with no section sub-score less than 16 (80.0)

iBT: (80.0)

IELTS: Students taking the IELTS must obtain a score of at least 6.5, with no subscore below 6.5 to be considered for admission to Virginia Tech. (6.5)

The overall goal of the Ph.D. Program in Business Administration with Concentration in Management (Management Ph.D. Program) is to develop students into future academics who are capable of conducting high quality research and publishing in top management journals. It is a full-time, residential, four-year program offered in the main campus Blacksburg. Students in their first two years take seminars that begin by helping them understand the core theories in management and develop basic research skills. Subsequent courses specialize in either macro areas (strategic management, entrepreneurship, and innovation) or micro areas (organizational behavior and human resources), as well as advanced topics in research methods and statistics. Students in their 3rd and 4th years spend most of their time working on dissertation research and developing research papers for submission to management journals. Students must also teach at least one course while in the Ph.D. program. We seek applicants who have the motivation for high quality

research and desire a career at a research university. Our program is designed to provide rigorous training in theory and methods and the opportunity to work closely with nationally and internationally renowned researchers so that our graduates have the skills necessary to succeed in their academic career. The following broad criteria are considered in evaluating applicants for admission to the Ph.D. Program in Management: Motivation and ability to conduct high-quality research that will allow placement at a top research university upon completion of their PhD; intellectual curiosity; ability to read, write, and speak English at a very high level; prior knowledge of business, research methods, and statistics. GMAT (we also consider GRE) scores are required to be considered for admission. New students are admitted to the program only in the fall semester.

GRADUATE COURSES (MGT)

MGT 5124:

Business Research Methods

Foundations of research methodology in business. Integrates research design, basic measurement and data analytic skills. Develops an understanding of quasi-experimental designs as a foundation for higher coursework in research design, measurement, and statistical analysis for business research. Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

MGT 5314:

Dynamics of Organization Behavior

This course examines the determinants and consequences of human behavior in formal organizations. The specific graduate focus is on understanding the individual, interpersonal, and group processes which underlie all human dynamics.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

MGT 5324:

Interpersonal Leadership for Managers

Develop a better understanding of leadership and the processes that underlie leadership effectiveness in complex organizational settings. Emphasis on utilizing and developing a personal approach to leadership. Interpersonal skills and communication; influence; leadership styles;

leading teams; critical thinking skills; conflict management; crucial conversations; and empowering creativity.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): MGT 5314

Corequisite(s):

MGT 5384:

Ethical Dimensions of Leadership

This course examines conduct in business within the context of moral philosophy. Emphasis is placed on the relevance of philosophical theories of morality to leadership and decision making in organizations.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

MGT 5424:

Business Negotiation: Strategies, Tactics and Skills

Examines negotiating as a process where two or more parties seek to build upon their common interests and manage their divergent ones. Both the context of negotiations and the skills of the parties in rational analysis and interpersonal relationships determine whether an agreement can be reached and the quality of the outcomes for the participants. Extensive use is made of simulated negotiation exercises followed by analysis of outcomes to enable students to practice applying concepts and theories developed by economists and social psychologists to concrete business cases. Pre-requisite: Graduate standing in the MBA program

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

MGT 5454:

International Business

Develop a perspective on the challenges and opportunities that corporations face in the global economy. Explore the socio-cultural, economic, political, and legal environments of international business takes place. Examine how multinational firms create competitive advantage from their network of worldwide operations. Relate major

business functions to the firms overall global strategy. The focus is on developing analytical and managerial skills to effectively compete in the increasingly interconnected world. Pre: Graduate standing

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

MGT 5464:

Corporate Acquisitions and Alliances

Modes to accomplish the firms corporate strategy and create corporate advantage, including mergers, acquisitions, alliances, joint ventures and corporate restructuring. Analytic and managerial skills for managing corporate development in traditional, large business settings in developed economies as well as in start-ups, the Internet/new economy and emerging economies.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): MGT 5314

Corequisite(s):

MGT 5594:

Technology and Innovation Management

This course takes a general managers perspective to examine the challenges of managing technology and innovation and their impacts on organizations. It provides students with a solid understanding of key concepts, tools, and frameworks useful in managing technology and innovation. Cases will also be used as a device for developing analytical and decision-making skills and for highlighting the reality of organizational and environmental complexities in managing technology and innovation. Pre-requisite: Enrollment in the Exec. or Prof. MBA program.

Credit Hour(s): 2

Lecture Hour(s): 2

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

MGT 5604:

Team Building

An introduction to teams in management including the justification for team formation. Practical considerations for developing teams to

improve personal and organizational effectiveness are covered, particularly in organizations where significant diversity is present.

Executive MBA students only.

Credit Hour(s): 1

Lecture Hour(s): 1

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

MGT 5614:

Designing & Managing Orgs

This course focuses on the implications of globalization and the resulting cross-cultural relationships for leaders and managers of business organizations. The ways in which culture affects characteristics of individuals, interpersonal relationships, negotiation styles, and leadership practices are examined. Cases and exercises develop skills in applying theories and concepts to concrete situation. Executive MBA students only.

Credit Hour(s): 2

Lecture Hour(s): 2

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

MGT 5634:

Strategic Business Environment

Course focuses on tools and techniques for industry and competitive analysis and describes methods used by organizations to develop and sustain a competitive advantage. Examples and cases from current business, single- and multi-business corporations in a variety of industries will be studied. Executive or Professional MBA program required.

Credit Hour(s): 1

Lecture Hour(s): 1

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

MGT 5654:

Strategic Human Resource Management

Examines current issues critical to the management of an organizations human capital assets. Critically examines how systems of human resource policies and practices can be used to enhance a firms competitive strategy and achieve competitive advantage in the

marketplace. Examines development and deployment of systems of human resource practices appropriate to specific organizational objectives and their impact on organizational effectiveness. Pre-requisite: Enrollment in the Professional MBA or the Executive MBA program.

Credit Hour(s): 2

Lecture Hour(s): 2

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

MGT 5664:

Ethical Leadership in a Global Context

This course examines significant issues in business ethics and the forms they take in different cultures. A stakeholder approach is adopted and attention is focused on firms relationships with four important stakeholders: employees, consumers, governments, and communities. Skills at stakeholder analyses are developed through the application of various ethical theories to case studies of problems encountered in different cultures. Creativity in resolving conflicts among stakeholders with different values and interests is fostered through participation in experiential negotiation exercises. Graduate standing required.

Executive MBA and Professional MBA students only.

Credit Hour(s): 1

Lecture Hour(s): 1

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

MGT 5674:

Leadership for Change Management

Study methods for changing organizations and individuals within those organizations using organizational transformation techniques, information technologies, and different leadership/personality styles.

Executive MBA students only.

Credit Hour(s): 2

Lecture Hour(s): 2

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

MGT 5684:

Global Management and Strategy

Management challenges associated with global competition and the

ways in which firms can create and sustain superior returns be formulating and implementing effective strategies. Develops an integrated, multi-functional, general management perspective of the organization. Comprehensive case studies of large firms will be used to develop students skills in strategic thinking, analysis, and execution. Strong emphasis is placed on the global environment. Pre-requisite: Enrollment in the Executive MBA program.

Credit Hour(s): 2

Lecture Hour(s): 2

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

MGT 5744:

Topics in Corporate Governance

Current issues and trends in corporate governance. Topics include overview of the corporation, stakeholder versus shareholder, board of directors, executive compensation, ownership structure, committee assignments, regulatory and legal environment, and firm performance. Graduate standing in the Professional MBA program required.

Credit Hour(s): 2

Lecture Hour(s): 2

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

MGT 5784:

International Management

This course focuses on the management challenges associated with the development of strategies and the management of organizations in business enterprises whose operations stretch across national boundaries. It will provide students with the knowledge, skills, and sensitivities that will help them manage more effectively in an international environment.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): MGT 5314

Corequisite(s):

MGT 5794:

Strategic Management

Examines business policy through a study of general managements task of strategy formulation and implementation. Comprehensive case

studies concerning a variety of organizations serve as a basis for analysis. Pre: Final term M.B.A. standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

MGT 5804:

Strategic Leadership in Technology-based Organizations

This course focuses on the role of the leader in crafting corporate and business strategies where technology provides the basis for the firms competitive advantage.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

MGT 5814:

Entrepreneurial Leadership

Concepts and techniques for providing leadership in the entrepreneurial venture. Provides the theoretical understanding of the entrepreneurial process in the economy as well as the practical leadership, marketing, financial and production considerations for entrepreneurial initiatives for new ventures and established firms.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

MGT 5824:

Technology-based Entrepreneurship

Entrepreneurship in technology-based startups, corporate, and public-sector organizations operating in digital environments. Experiential activities in commercialization and resource mobilization strategies.

Design and validation of digital business models for launching technology-based ventures. Assessment and pursuit of entrepreneurial opportunities in cybersecurity, automation, artificial intelligence, and machine learning. Master of Information Technology (MIT) students only.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): MGT 5804 OR ECE 5484

Corequisite(s):

MGT 5844:

Business & Corporate Strategy

Focus on strategic decisions of the firm and use of tools and techniques for external and internal analysis to develop and sustain a competitive advantage. Examples and cases of single and multi-business corporations in a variety of industries, both domestic and international.

Prerequisite: Enrollment in Executive MBA program.

Credit Hour(s): 2

Lecture Hour(s): 2

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

MGT 5854:

Ethics and Leadership in a Global Environment

Ethical issues in business and management using both a theoretical and a case study approach. Relevance of philosophical theories of morality and alternative views of corporate social responsibility to leadership and decision making in organizations. Pre: Graduate Standing.

Credit Hour(s): 2

Lecture Hour(s): 2

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

MGT 5894:

Final Examination

NONE

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

MGT 5905:

Business Analytics Capstone

Management and execution of business analytics projects. Problem and scope definition, identifying objectives, data requirements and preparation, selection of software tools, project planning and administration, leadership and team building, and assessment of project

value and effectiveness. Pre: Graduate Standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

MGT 5906:

Business Analytics Capstone

Management and execution of business analytics projects. Integrated application of analytics knowledge, techniques, and tools resulting in the development and delivery of insights, recommendations, and expected outcomes to corporate stakeholders in professional communications, presentations, and reports. Pre: Graduate Standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): MGT 5905

Corequisite(s):

MGT 5954:

Study Abroad

NONE

Credit Hour(s): 1 TO 6

Lecture Hour(s): 1 TO 6

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

MGT 5964:

Field Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

MGT 5974:

Independent Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Independent Study, VI

Instruction Type(s): Independent Study, VI

Prerequisite(s):

Corequisite(s):

MGT 5984:

Special Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

MGT 5994:

Research and Thesis

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research

Instruction Type(s): Research

Prerequisite(s):

Corequisite(s):

MGT 6024:

Foundations of Management Theory

Theory development in management research. Theoretical models and perspectives as an intellectual foundation for management research.

Individual-, team-, and firm-level management theories applied to the evaluation, testing, and advancement of management research. Pre:

Graduate standing

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

MGT 6104:

Advanced Research Studies

Students will carry out a theoretical or empirical research project, produce a research paper, present the research findings to the departmental faculty and students, and submit the manuscript for presentation at a professional meeting or for publication in an academic journal. Pre: Six hours of graduate statistics, completion of the first year

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

MGT 6224:

Applied Measurement in Business Research

Design and analysis of measures for use in business research.

Measurement validity and reliability concepts to contexts such as personnel selection, market research, and employee/customer attitudes.

Selective, intensive discussion of measurement topics in business research, including observed vs. unobserved variables in measurement; biases stemming from the use of particular methods; exploratory vs. confirmatory approaches to measurement; appropriate application of control variables.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): MGT 5124

Corequisite(s):

MGT 6704:

Strategic Management and Organization Theory Seminar

Current and classical theories in strategic management and organization theory will be examined. Students will identify and assess basic assumptions, fundamental research questions and opportunities, and limitations of these theories.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

MGT 6714:

Organizational Behavior Theory Seminar

Foundational and contemporary paradigms and theories supporting organizational behavior and research are examined. How these paradigms and theories shape, constrain, and foster the development of research is explored. Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

MGT 6724:

Review of Strategic Management & Organizational Theory Research

Current research in strategic management and organizational theory will be examined. Students will assess fundamental research questions, opportunities, and limitations of this research. Current research methods in strategic management and organization theory will be discussed and examined. Pre-requisite: Graduate Standing

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

MGT 6734:

Review of Research in Organizational Behavior & Human Resources Management

Current research in organizational behavior and human resource management will be examined. Students will assess fundamental research questions, opportunities, and limitations of this research. Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

MGT 6744:

Management Research Practicum

Review of the scholarly research process and standards for top-tier journals. Writing and revising research papers using the standards. Development of research questions and theory, match of theory and research design, data analysis and presentation of results, articulation of contributions, and revision of manuscripts. Critique research papers and practice writing reviews. Pre: Graduate Standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

Graduate Seminar in Management Research

Presentation and critical discussion of current literature and major topics in management research. The seminar provides a forum for the discussion of research and research problems in management and the presentation of research by graduate students. Provides students an opportunity to prepare and present current work related to their dissertation, and to engage in other activities related to the promotion of their professional development. Pre: Graduate standing.

Credit Hour(s): 1

Lecture Hour(s): 1

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

MGT 6984:

Special Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

MGT 7994:

Research and Dissertation

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research, Online Research

Instruction Type(s): Research, Online Research

Prerequisite(s):

Corequisite(s):

BUSINESS, MARKETING

Rajesh Bagchi, Head

Professors: David Brinberg; Dipankar Chakravarti; Eloise Coupey; Rowena Crabbe; Shreyans Goenka; Paul Herr; Juncai Jiang; Shilpa Madan; Frank May; Mario Pandelaere; Broderick Turner; Yan Xu;

Graduate Contact: ababer3@vt.edu

Graduate Site: <https://marketing.pamplin.vt.edu>

Doctoral Program in Marketing: <https://marketing.pamplin.vt.edu/prospective->

[students/prospective-phd.html](https://marketing.pamplin.vt.edu/prospective-phd.html)

The Department of Marketing participates in the Pamplin College of Business MBA programs and offers two focused programs – an M.S. in Business with Concentration in Marketing focused on marketing research and Ph.D. in Business with Concentration in Marketing focused on basic research in marketing. The program is highly selective, rigorous, and personalized. The size of the program is strictly controlled to allow for intensive faculty-student collaboration. The required coursework provides rigorous exposure to the academic research literature in marketing as well as research methods and statistics. At the same time, we recognize that students bring a variety of interests and we will work with students to develop programs of study that will allow them to productively pursue those interests. The department will commit up to four years of financial assistance to students enrolled in the Doctoral Program in Marketing, assuming satisfactory academic progress is being made. Additional financial support may be available through summer teaching. For students interested in careers in marketing management, information is available on the Marketing website: www.marketing.pamplin.vt.edu. For students interested in the MBA program, information is available at <http://www.mba.vt.edu>.

SPECIAL FACILITIES

Behavioral Research Laboratory--The Department of Marketing manages the College's behavioral research laboratory. The lab maintains computer stations, some isolated, for data collection. Group tasks and interviews can be accommodated. Graduate students in Marketing have access to the lab facilities.

Department of Marketing

Department of Marketing- 880 West Campus Drive, 2016 Pamplin Hall (0236), Blacksburg, VA 24061

DEGREES OFFERED

MS Degree

Offered In (Blacksburg)

TOEFL

Paper: (600.0)

Computer: (250.0)

iBT: (100.0)

M.S. Overview The Marketing Department offers a Master of Science in Business with Concentration in Marketing focused on advanced marketing research. The program serves students who wish to pursue a Ph.D. but who have completed only an undergraduate degree. The program involves a high level of interaction with members of the marketing faculty. The M.S. program provides a point of entry for students with limited backgrounds, allowing them to gain insight on the training and career expectations for Ph.D.'s in marketing and to complete work preparatory to Ph.D. study in core areas like mathematics, statistics, and research methods. Prospective applicants should understand that this program is not a substitute for the M.B.A. for students seeking a professional business degree, given its function as a gateway to the Ph.D. program. The M.S. and Ph.D. programs are highly selective and limited in size (admitting 1 to 3 students per year across both programs). We aim to admit promising candidates with a keen

interest in academic research. M.S. Requirements The program of study includes a minimum of 30 credit hours of coursework at the graduate level, plus a thesis. The degree requirements include: - 9-12 credit hours of advanced marketing seminars (6000 level). - Minimum of 9 credit hours of research methods and statistics courses at the graduate level. Suggested courses include graduate study in statistics (STAT 5615, 5616, or 5004), econometrics (ECON 5125, 5126, 5127), psychology (PSYC 5315, 5316), and/or marketing (MKTG 6224). - 6-9 elective credit hours at the graduate level in a related discipline or graduate-level business courses that would contribute to the student's ability to design and conduct sophisticated research. - A comprehensive applied project entailing the design and implementation of appropriate marketing research skills, an examination covering the marketing literature and research methods, or a master's thesis with up to 6 credit hours awarded. - A master's thesis. Up to 6 credit hours will be awarded for the thesis.

PhD Degree

Offered In (Blacksburg)

TOEFL

Paper: (600.0)

Computer: (250.0)

iBT: (100.0)

Ph.D. Overview The Doctoral Program in Marketing (Ph.D. in Business with Concentration in Marketing) is designed to develop graduates who assume positions as faculty members in research-oriented schools of business. The faculty has developed the doctoral program in marketing to provide challenging research and learning experiences for students seeking the skills to become leading researchers and communicators of advanced business knowledge. The key ingredients to the program's success are its excellent students and its dynamic, research-oriented faculty who publish regularly in the leading marketing journals. In addition, faculty members are active in national marketing associations such as The American Marketing Association, The Association for Consumer Research, The Society for Consumer Psychology, and INFORMS Society of Marketing Science. The program is highly selective, rigorous, and personalized. The size of the program is strictly controlled to allow for intensive faculty-student collaboration. The required coursework provides rigorous exposure to the academic research literature in marketing as well as research methods and statistics. At the same time, we recognize that students bring a variety of interests and we will work with students to develop programs of study that will allow them to productively pursue those interests. The M.S. and Ph.D. programs are highly selective and limited in size (admitting 1 to 3 students per year across both programs). We aim to admit promising candidates with a keen interest in academic research. Ph.D. Requirements As the student advances through the doctoral program, the focus of the program shifts from coursework to research activity. Following completion of the doctoral seminars in the first year, each student is required to write a first-year research proposal paper; at the end of the second year, students are expected to write a more comprehensive second-year research proposal paper. The research papers serve as qualifying examinations. Students failing the qualifying examination, either in the first or second year, will be asked to leave the doctoral program. The program of study includes a minimum of 90 credit hours of coursework at the graduate level, plus a comprehensive project, examination, or a thesis. The degree requirements include: - Coursework in marketing content and theory, statistics, research methodology, and one supporting minor that should be consistent with

the students interests and professional goals. - A series of marketing doctoral seminars are required during the first two years of study such as MKTG 6105, 6106, 6304 focusing on marketing literature and current issues in the academic research field with MKTG 6224 focusing on research methods. - At least two courses of graduate statistics must be taken beyond STAT 5615 and 5616 or equivalent, along with at least three courses in the chosen minor field. - A major aspect of learning is the student-faculty relationship. This one-on-one interaction is emphasized early in the program through research assistantships and independent studies. - Completion of a qualifying examination after the first year of studies to build on the work completed to date. Students failing the qualifying examination will be asked to leave the doctoral program. - Doctoral students are required to develop and present original research in seminar classes. Students will be expected to submit original research, some co-authored with a member of the faculty, to major conferences and later to marketing journals. - Students are required during their third year of study to develop a dissertation proposal and defend it. This defense constitutes the University-required Preliminary Examination. - The fourth year of the doctoral program is focused on the pursuit of dissertation research. - The final oral examination, including the defense of the dissertation, is administered after completion of the dissertation.

GRADUATE COURSES (MKTG)

MKTG 5104:

Marketing Policy And Strategy

Principles and processes of strategic marketing planning. Emphasis on development and implementation of marketing plans and programs.

Comprehensive case studies are used as the basis for analysis.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ACIS 5104

Corequisite(s):

MKTG 5154:

Research for Marketing Decisions

The course encompasses: problem formulation, research design, data gathering instruments, scaling, sampling, data analysis for making marketing-related decisions, and solving marketing-oriented problems.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): MKTG 5104

Corequisite(s):

MKTG 5204:

Consumer Behavior

Consumer decision-making; information processing; perception; attitude; motivation; social and cultural influences on purchasing behavior; applications to marketing plan, target marketing, product development, distribution, pricing, and promotion.

Credit Hour(s): 2

Lecture Hour(s): 2

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): MKTG 5654

Corequisite(s):

MKTG 5254:

Product Strategy

Strategic product planning and new product development within the context of marketing. Topics include the role of the product manager, strategic marketing planning, product/market identification, new product development, and diffusion of innovations.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): MKTG 5104

Corequisite(s):

MKTG 5304:

Promotion Strategy

Emphasis on understanding and applying the principles of marketing communication from a managerial perspective. Course examines the marketing communication activities of an organization focusing on the economic, sociological, and psychological aspects of behavior.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): MKTG 5104

Corequisite(s):

MKTG 5444:

Marketing, Management and the Public Purpose

The social context of business, with particular attention to marketing practices and entrepreneurial ventures. Examination of the public policy issues that arise from the pursuit of capitalist enterprise as well as the role of marketing and entrepreneurship in advancing social welfare and economic development. Multi-disciplinary approach linking historical, socio-cultural, political/legal, ethical, and strategic analyses in a global context.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): MKTG 5104, MGT 5314

Corequisite(s):

MKTG 5604:

Marketing Principles

An introduction to marketing management for executive MBA students. Considers the principles and processes of marketing planning in business and non-profit organizations. Executive MBA students only.

Credit Hour(s): 2

Lecture Hour(s): 2

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

MKTG 5614:

Marketing Analysis and Strategy

Study of methods for analyzing customers (particularly market segmentation), diagnosing competitive market structure, and forecasting demand and the use of this information to develop marketing strategy. Executive MBA students only.

Credit Hour(s): 2

Lecture Hour(s): 2

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

MKTG 5624:

Business Negotiations

This course addresses the practice of successful negotiations in business, including the business activities of marketing, operations, finance, and information management. This course utilizes behavioral principles of negotiation to develop and refine students understanding and practice of effective negotiating skills. Executive MBA students only.

Credit Hour(s): 2

Lecture Hour(s): 2

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

International Marketing Management

This course focuses on marketing decision making in a global context. The course includes consideration of the impact of culture, politics, and economics and the resulting differences in marketing institutions, marketing decision making, and marketing strategy.

Credit Hour(s): 2

Lecture Hour(s): 2

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): MKTG 5604

Corequisite(s):

MKTG 5654:

Managing the Mktg Function

Concepts of marketing management in a global environment, including the role of marketing in business organizations, and the relationship of marketing to other organizational functions. Role of marketing for developing and sustaining a competitive advantage in the marketplace, based of effective managerial decision making. Covers new product development and branding, as well as the characteristics of effective target marketing. Emphasis on the role of developing appropriate business intelligence for strategic decision making. Pre-requisite:

Enrollment in the Executive MBA program

Credit Hour(s): 2

Lecture Hour(s): 2

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

MKTG 5664:

Managing MKTG Relationships

Factors that influence development of professional relationships necessary to create long-term satisfaction and commitment to the firm and its services. Integrates research and best practices in professional services with concepts of relationship marketing to provide practical knowledge of how to develop the network of relationships, both internal (e.g., staff) and external (e.g., customers, suppliers, investors, media) needed to develop a sustainable supply of goods and services.

Credit Hour(s): 2

Lecture Hour(s): 2

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): MKTG 5654

Corequisite(s):

MKTG 5674:

Marketing in Dynamic Contexts

Strategic decision making to balance the interests of organizations (both profit and nonprofit) with those of society. Examination of public policy issues that arise from the pursuit of capitalist enterprise, as well as the role of marketing and entrepreneurship in advancing social welfare and economic development. Multi-disciplinary approach links historical, socio-cultural, political/legal, ethical, and strategic analyses in a global context.

Credit Hour(s): 2

Lecture Hour(s): 2

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): MKTG 5664 (UG)

Corequisite(s):

MKTG 5704:

International Marketing Strategy

This course provides the background to make managerial marketing decisions at the international level. It is composed of four sections: macro dimensions of international marketing, e.g., culture, politics, and economics; international comparative marketing systems; international marketing management decisions; and international strategic planning and control.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): MKTG 5104

Corequisite(s):

MKTG 5894:

Final Examination

NONE

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

MKTG 5904:

Project and Report

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research, Online Research

65 Instruction Type(s): Research, Online Research

Prerequisite(s):

Corequisite(s):

MKTG 5954:

Study Abroad

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

MKTG 5974:

Independent Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Independent Study, VI

Instruction Type(s): Independent Study, VI

Prerequisite(s):

Corequisite(s):

MKTG 5984:

Special Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

MKTG 5994:

Research and Thesis

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research, Online Research

Instruction Type(s): Research, Online Research

Prerequisite(s):

Corequisite(s):

MKTG 6105:

Advanced Topics In Marketing

6105: Seminar in marketing theory, marketing research, buyer behavior,

and marketing strategy. Emphasis on conceptual and methodological developments in marketing. 6106: Seminar in marketing management. Emphasis is placed on conceptual and methodological developments and quantitative decision models in promotion management, product and price management, channel of distribution management, and sales force management. May be repeated for credit up to 9 hours for each seminar with different content. II.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

MKTG 6106:

Advanced Topics In Marketing

6105: Seminar in marketing theory, marketing research, buyer behavior, and marketing strategy. Emphasis on conceptual and methodological developments in marketing. 6106: Seminar in marketing management. Emphasis is placed on conceptual and methodological developments and quantitative decision models in promotion management, product and price management, channel of distribution management, and sales force management. May be repeated for credit up to 9 hours for each seminar with different content. II. Permission of Instructor.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): MKTG 6105

Corequisite(s):

MKTG 6204:

Judgement and Decision Making Research in Marketing

Selective, intensive exposure to research in key substantive and methodological areas related to consumer and marketing managerial judgment and decision making. Design and implementation of original research. Key factors that influence consumer buying and marketing managerial decision making, including the role of utility theory; heuristics and biases; mental accounting and framing; risk; context effects; temporal effects; perceptual and cognitive processes; emotion; motivated and counterfactual reasoning; and motivational influences. Pre: Graduate Standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

MKTG 6224:

Advanced Marketing Research

Issues related to research design, measurement and scaling, and data collection procedures. Methods for doing integrative research reviews are also covered. Six hours of graduate statistics required. II

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): MKTG 5154, MKTG 6214

Corequisite(s):

MKTG 6234:

Experimental Methods in Business Research

Experimental research methods for business research. Design of experimental studies, practical issues, and analysis of data. External, construct, and internal validity issues. Statistical techniques such as Analysis of Variance (ANOVA) and General Linear Model extensions. Hypothesis testing of causal mechanisms, result reporting, and replicability concerns. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

MKTG 6244:

Advanced Quantitative Research Methods in Business

Theoretical foundations of quantitative research techniques used in business research. Sources of secondary data and primary data collection methods. Locating, reading, organizing, cleaning, and storing large datasets for model estimation. Statistical analysis using current statistical packages. Identification of natural experiments in business research and quantitative techniques to obtain the treatment effect. Application of methods to empirical research in all areas of business. Professional statistical result reporting in business research. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

MKTG 6304:

Seminar in Buyer Behavior Research

This course applies current psychological, social psychological, sociological, communication, and economic theories and research to the study of buyer behavior phenomena. Emphasis is placed on recent research findings and methodologies in buyer behavior.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): MKTG 5154

Corequisite(s):

MKTG 6404:

Advanced Quantitative Marketing Methods

Theory, method, and application of selected quantitative methods for marketing: linear structural relations, path analysis, canonical and discriminant analysis, and exploratory and confirmatory factor analysis. Special purpose methods such as conjoint analysis, multidimensional scaling, cluster analysis, and recent methodological developments also will be covered.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): MKTG 5154

Corequisite(s):

MKTG 6444:

Seminar in Marketing & Society

The role of marketing in society from the standpoint of consumer welfare, including ethical considerations, economic analyses of consumer welfare, and social choice. Implications for transformative consumer research, social marketing, and public policy. Conceptual and methodological developments in academic research from marketing and related disciplines. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

MKTG 6984:

Special Study

NONE

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

MKTG 7994:

Research and Dissert

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research, Online Research

Instruction Type(s): Research, Online Research

Prerequisite(s):

Corequisite(s):

BIOMEDICAL ENGINEERING

Joel Stitzel, Head

Jennifer Wayne, Head

Professors: Luke Achenie; Masoud Agah; Graca Almeida-Porada; Evelyn Anthony; Anthony Atala; Warren Bickel; Myra Blanco; John Bourland; Rafael Davalos; Thomas Diller; Stefan Duma; Kevin Edgar; Wu-Chun Feng; Michael Friedlander; Hampton Gabler; Harold Garner; Francis Gayzik; William Gmeiner; Robert Gourdie; Metin Gurcan; Adam Katz; Daniel Kim-Shapiro; Michael Kolodney; Paul Laurienti; Alexander Leonessa; Liwu Li; Timothy Long; Chang Lu; Michael Madigan; Pendleton Montague; Michael Morykwas; Andre Muelenaer; Michael Munley; T Murali; Maury Nussbaum; Emmanuel Opara; Boris Pasche; Mark Paul; Olga Pierrakos; Padmavathy Rajagopalan; Shane Ross; John Rossmeisl; Beverly Rzigalinski; Hooman Sadri-Ardekani; Webster Santos; Thomas Smith; Shay Soker; Harald Sontheimer; Joel Stitzel; Mark Stremler; Danesh Tafti; Pamela VandeVord; William Wagner; Layne Watson; James Yoo; Wei Zhang;

Associate Professors: Bahareh Behkam; Kerry Danelson; Raffaella De Vita; Zachary Doerzaph; Aaron Goldstein; Craig Hamilton; Warren Hardy; William Huckle; Andrew Kemper; Brooks King-Casas; Charlie Klauer; Stephen LaConte; Yong Lee; Xin Ming; Amrinder Nain; Kristen Nicholson; Michelle Olsen; Miguel Perez; Steven Poelzing; Christopher Porada; Robin Queen; Edgar Romero-Sandoval; Steven Rowson; Eva Schmelz; Sean Simpson; John Socha; Anne Staples; Michelle Theus; Umit Topaloglu; Costin Untaroiu; Mark Van Dyke; Scott Verbridge; Vincent Wang; Christopher Whitlow; Abby Whittington; Chris Wyatt; Yong Xu; Jianhua Xuan; Saami Yazdani; Dawen Zhao;

Assistant Professors: Irving Allen; Christopher Arena; Sara Arena; Kristen Beavers; Philip Brown; Matthew Buczynski; John Chappell; Arjun Chatterjee; Christina Cramer; Tracy Criswell; John Domann; Xin Feng; Howard Gage; Adam Hall; Erin Henslee; Blake Johnson; Jennifer Jordan; Youngkyoo Jung; Sohan Kale;

Deborah Kelly; Bethany Kerr; Kenneth Kishida; Sang Lee; Nicole Levi; Sarah McDonald; Alexei Morozov; Konark Mukherjee; Jennifer Munson; Sean Murphy; Alexander Powers; Elaheh Rahbar; Divya Srinivasan; Rong Tong; Jillian Urban; James Ververs; Pierre-Alexandre Vidi; Sujith Vijayan; Eli Vlaisavljevich; Ashley Weaver; Jared Weis; Jeff Wiley; Yizheng Zhu;

Affiliated Faculty: Sandeep Mittal;

L. Preston Wade Professor: Rafael Davalos;

Samuel Herrick Professor: Hampton Gabler;

Harry C. Wyatt Professor: Stefan Duma;

H. G. Prillaman Professor: Maury Nussbaum;

Robert E. Hord Professor: Padmavathy Rajagopalan;

Research Professors: John Robertson;

N. Waldo Harrison Professor: Pamela VandeVord;

Kevin P. Granata Fellow: Vincent Wang;

Fred W. Bull: Chang Lu;

General Contact: amturne3@vt.edu

Program Web Site: <https://beam.vt.edu/graduate/biomedical.html>

Department Web Site: <http://www.beam.vt.edu>

The Virginia Tech – Wake Forest University School of Biomedical Engineering & Sciences (SBES) is a unique multidisciplinary program which couples the biomedical sciences, biomedical engineering, and real-world applications to enhance the quality of life. Our world-class faculty and students innovate and discover across a continuum of systems, from natural to engineered to medical. SBES is a fully joint graduate program formed in 2003 that brings together three prestigious academic units: the Virginia Tech College of Engineering, the Wake Forest School of Medicine, and the VA-MD College of Veterinary Medicine. Each of these separate entities contributes unique strengths to the combined enterprise so that students are offered a wide spectrum of first-class educational and research opportunities in a beautiful part of the country. The SBES program is available to students at two campus locations. Blacksburg, Virginia is home to the VT College of Engineering and the VA-MD Veterinary College, both of which provide faculty to the program. Winston-Salem, NC is the home of the Wake Forest University Baptist Medical Center consisting of Wake Forest University Health Sciences and North Carolina Baptist Hospital. Contributors to SBES include the clinical departments and the Department of Biomedical Engineering. SBES is a graduate level only program offering the following degree programs: M.S. in Biomedical Engineering Ph.D. in Biomedical Engineering DVM/PhD offered through the Veterinary School in Blacksburg MD/Ph.D. offered through the Wake Forest University School of Medicine. Accelerated undergraduate/graduate option (currently only at Virginia Tech) The SBES curriculum currently consists of courses and research focused in 9 broad areas of concentration which include: Automotive Safety Biomaterials Biomechanics Biomedical Imaging Cardiovascular Engineering Nanomedicine & Nanobioengineering Neuroengineering Tissue Engineering Translational Cancer Research SBES encourages innovative thinking and novel approaches to problem-solving and seeks to tailor students' academic programs to their individual goals and research ambitions. Please refer to the SBES handbook for further details regarding concentrations. One campus is chosen as the "home campus" but students have the opportunity to experience both environments and the faculty of each through courses taught by video broadcast and by inter-campus visits.

Many research projects are collaborative efforts between faculty and students across the two locations. All PhD students experience a required Clinical Rotation course much of which is given at the Medical Center in Winston-Salem. Students successfully completing a graduate program in SBES will receive a joint degree from Virginia Tech and Wake Forest University. The diploma displays the names and seals of both institutions.

SPECIAL FACILITIES

On the Blacksburg campus SBES occupies Kelly Hall, on Stanger Street with approximately 30,000 sq. ft. of laboratory space designed specifically for cutting-edge biomedical research. Also available to graduate students at Blacksburg are the superior facilities of the Veterinary College (VMRCVM) which is part of the SBES alliance, the Virginia Bioinformatics Institute, located on the VT campus, and most recently the Virginia Tech Carilion School of Medicine and Research Institute (VTCRI) located in Roanoke, VA. At Winston-Salem SBES students have access to top quality research resources through the Wake Forest University School of Medicine and its affiliation with North Carolina Baptist Hospital, one of the finest in the country. Additionally, SBES has ties to the Wake Forest Institute for Regenerative Medicine (WFIRM), an international leader in bringing cell and tissue engineering discoveries to clinical therapies. The WFIRM and other research groups are part of a 200-acre biotechnology initiative at the Piedmont Triad Research Park which will be the largest urban research park of its kind in the nation.

Advanced Neuroscience Imaging Research Core (ANSIR) [Winston-Salem]

The Advanced Neuroscience Imaging Research (ANSIR) Laboratory is a research group based in the Department of Radiology of Wake Forest University School of Medicine. The lab is devoted to the application of novel image analysis methods (e.g. diffeomorphic registration, machine learning, graph theory, ASL) to research studies, as well as to robust clinical translation of these techniques. The lab also maintains a fully automated functional and structural image processing pipeline supporting the image storage and analysis needs of a variety of scientists and imaging studies at Wake Forest. [Website Here](#)

Bio-imaging Systems Lab [Blacksburg]

The purpose of the Bio-imaging Systems Lab is to develop technologies to accelerate the use of imaging and image analysis in biomedicine. An important part of this goal is communicating with the clinical and basic scientists who benefit from our work. [website here](#)

Bioanatomic Imaging and Treatment Program [Winston-Salem]

The Bioanatomic Imaging and Treatment (BAIT) Program is a clinical and research program at North Carolina Baptist Hospitals and Wake Forest University School of Medicine. BAIT clinical and basic research focuses on the uses of bioanatomic imaging and treatment for patients who have cancer, on understanding the biological mechanisms of cancer as can be seen with imaging, and on radiation treatment responses. Our scientific programs include image-based clinical trials and basic research in imaging science and radiation treatment physics. [website here.](#)

Bioelectromechanical Systems Lab [Blacksburg]

Bioelectromechanical Systems is a cross disciplinary field that combines engineering and science from the nano to the macro level. In our laboratory we have developed technology for tissue viability detection, picoliter sample management, and imaging for molecular medicine. We have developed three inexpensive solutions that use electrical feedback to perform complex procedures in biotechnology with precision and control. Through this engineering approach, we have established robust methods for single cell analysis, selective cell concentration, and cancer therapy. [website here.](#)

Biomedical Imaging Division [Blacksburg and Winston-Salem]

The mission of the Biomedical Imaging Division is to define and advance biomedical imaging frontiers, optimize clinical / preclinical potentials, and train the next generation of imaging scientists and engineers. It consists of two x-ray imaging laboratories; the SBES Advanced Multi-scale CT (SAM-CT) lab and the X-ray Systems Lab. The two labs house four commercial CT imaging systems and two custom-built CT imaging systems. Together they provide image resolution from 500 micrometers down to 50 nanometers, and sample size from 100 micrometers up to 100 millimeters, enabling biomedical discovery on a range of objects from a single cell to an adult rat. [website here](#)

Center for Biomolecular Imaging [Winston-Salem]

The Center for Biomolecular Imaging (CBI) is a multi-technology Medical School facility comprised of state-of-the-art imaging modalities. Its purpose is to support imaging research while facilitating multidisciplinary research. Part of its mission is to change the imaging research paradigm from pathoanatomy to imaging opportunities related to physiologic/functional imaging and molecular imaging. [Website Here](#)

Center for Injury Biomechanics [Blacksburg and Winston-Salem]

The Center for Injury Biomechanics performs research investigating human tolerance to impact loading. The application of this research includes automobile safety, military restraints, and sports biomechanics. The Center combines experimental testing with anthropomorphic test drivers and computational modeling in order to develop human impact injury criteria. [Website Here](#)

Center for Nanotechnology and Molecular Materials [Winston-Salem]

Nanotechnology is engineering at the molecular level. At Wake Forest University's Nanotech Center the revolutionary principles of nanotechnology are being used to address the pressing needs of human society from health care to green energy technologies. The Nanotech Center is a shared resource serving academic, industrial, and governmental researchers across the region. We welcome researchers from any discipline who wish to explore uses of nano-materials and nanotechnologies in their work. [Website Here.](#)

Center for Regenerative Medicine [VT-Carilion, Roanoke]

The research of the lab is on the subunit proteins of gap junctions -- connexins. Our work encompasses both basic and

practical/translational aspects. In basic research we study cellular and molecular mechanisms of the carboxyl terminal domain of Cx43 in regulating gap junction remodeling and electrical conduction in the normal and arrhythmic heart. In our more practically oriented work, we focus on Cx43 assignments in wound healing, scarring, and regeneration. The lab is developing a platform of drugs targeting Cx43 function. [website here](#)

Chappell Lab [VT-Carilion, Roanoke]

Pericytes are cells that wrap around blood vessels to maintain their stability and regulate their diameter through vasomotion. Disruptions in pericyte contribution to the vascular wall can lead to disease progression including diabetic retinopathy. Dr. Chappell and his lab use computational modeling approaches in conjunction with real-time imaging of ex vivo and in vitro models of blood vessel formation to understand pericyte behavior during blood vessel formation in health and disease. Understanding the mechanisms behind pericyte recruitment and investment will provide rationale and guidance for targeting pericyte-endothelial cell interactions for therapeutic benefit.

Comprehensive Cancer Center [Winston-Salem]

Because research brings hope, basic science, clinical and public health researchers at the Comprehensive Cancer Center of Wake Forest University collaborate to answer complex questions that lead to promising new treatments and therapies. The research programs are structured to optimize multidisciplinary and translational research. Our researchers work together to take the most promising discoveries from the laboratory into the clinic for the benefit of our patients and the cancer community as a whole. [Website here.](#)

Computational Bioinformatics & Bio-imaging Laboratory [Northern Virginia]

We are electrical and computer engineering researchers by training who have developed a great interest in multiscale, computational, integrative, and system biomedical sciences, mainly inspired by our curiosity about the process of discovery. We enjoy close collaborations with biologists and physicians, and these partnerships provide us with the opportunities to learn new things, to ask new questions, and to pursue new discoveries. [Website Here](#)

Crash Injury Research & Engineering Network (CIREN) [Blacksburg and Winston-Salem]

The Crash Injury Research and Engineering Network (CIREN) is a multi-center research program involving a collaboration of clinicians and engineers in academia, industry, and government. Together, they are pursuing in-depth studies of crashes, injuries, and treatments to improve processes and outcomes. CIREN's mission is to improve the prevention, treatment, and rehabilitation of motor vehicle crash injuries to reduce deaths, disabilities, and human and economic costs. [Website here](#)

Human Neuroimaging Laboratory [VT-Carilion, Roanoke]

The Human Neuroimaging Laboratory (HNL) is part of the Virginia Tech

Carilion Research Institute, located in Roanoke, Virginia. Research projects cover a wide variety of fields, including neuroscience, psychology, political science and economics. Particular areas of interest are hyperscanning (a means of exploring brain activity that underlies human social interactions), social neuroscience, neural circuitry of valuation and decision-making, and disruptions of such processes associated with developmental and psychiatric illness. The HNL serves as the primary imaging facility of the VTCRI. [Website here](#)

Institute for Critical Technology and Applied Science (ICTAS) [Blacksburg]

The Institute for Critical Technology and Applied Science supports and promotes cutting edge research at the intersection of engineering, science and medicine. ICTAS stimulates, catalyzes, and promotes growth of research at Virginia Tech. ICTAS provides a collaborative atmosphere designed to stimulate and promote creativity, a place where intellectual capacity can be explored and challenged to reach areas previously explored in isolation. [Website Here](#)

Kelly Lab [VT-Carilion, Roanoke]

Research in the Kelly Lab at VTCRI focuses on developing innovative methodologies to study complex biological machinery. Combinations of structural and functional tools are used to understand how signaling pathways influence human development and disease. Cryo-Electron Microscopy (EM) allows us to peer into the world of cells and molecules around us. Affinity Capture technology is an innovative platform for visualizing molecules in action. We are developing this approach to transform our vision of the molecular world. [Website here](#)

Kevin P. Granata Biomechanics Lab [Blacksburg]

Our mission is to investigate the dynamics and neuromuscular control of human movement, and to train scientists to become leaders in the fields of musculoskeletal, sports and orthopaedic biomechanics. The primary focus of the research conducted in the Granata Lab is injury prevention. Projects in the lab fall into 3 main categories: Athletic Injury Prevention, Lower Extremity Joint Arthritis and its impact on Movement, and Alterations to Movement that result from injury and pathology.

LaConte Lab [VT-Carilion, Roanoke]

Research in the LaConte Lab is devoted to advanced neuroimaging acquisition and data analysis approaches, aimed at understanding and rehabilitating neurological and psychiatric diseases. A major focus of the lab is an innovation in functional magnetic resonance imaging (fMRI) which we developed and call "temporally adaptive brain state" (TABS) fMRI. The inception of TABS arose from two major recent advances in neuroimaging, namely 1) the recognition that multi-voxel patterns of fMRI data can be used to decode brain states and 2) the emergence of real-time fMRI as a viable tool for neurofeedback. [website here.](#)

Laboratory for Biomaterials and Tissue Engineering [Blacksburg]

Our research focuses on the development of model tissue constructs or functional tissue units and the study of cell-substratum interactions. A

primary goal is to design tissue constructs that mimic the native structure of tissues in-vivo and to systematically probe cellular response to a variety of cues. This involves the fabrication of bio-compatible scaffolds and templates, and more importantly tailoring surface and bulk properties. Another research interest of our group is to quantify cell-substratum interactions. Specifically, our studies focus on how chemical and mechanical properties of an underlying substratum affect cellular motility and contractility. Website Here

Laboratory for Complex Brain Networks [Winston-Salem]

The LCBN is a Wake Forest Baptist Health neuroscience and neuroimaging research facility located on the Medical Campus of Wake Forest University. It consists of an association of scientists located at universities, laboratories and research centers around the world that focus on imaging technology and emergence in complex systems. The primary focus of the laboratory is the development of innovative ideas, methods, and technologies for systematic understanding of emergence in dynamic complex systems such as the brain. Through the development and use of network science methods, the work of the LCBN offers a means to quantify and analyze networks of complex systems. Website here

Laboratory for Fluid Dynamics in Nature [Blacksburg]

The research at the Laboratory for Fluid Dynamics in Nature (FiNLab) is focused on two main themes: fluid flows in nature, and advanced computational methods for fluid flows. The natural systems studied at FiNLab range from insect respiratory flows, which occur at the microscale, to planetary atmospheric flows with length scales on the order of tens of kilometers. There is an emphasis on biomimetics for efficiency, resilience, and sustainability, on high performance computing, and on advanced multiscale computational modeling website here.

Laboratory of Vascular Biology [Blacksburg]

There are three main focus areas involved in the research efforts of the vascular biology lab: a) Pro-oxidative and pro-inflammatory mechanisms of human chronic vascular disease, such as stroke, atherosclerosis, Alzheimer's disease, and tumor angiogenesis/metastasis. b) Biomedical applications of nanotechnology: novel therapeutic explorations for brain injury and cancer progression by vascular endothelial cell targeting of bioconjugated nanoparticles. c) Cellular and molecular signaling mechanisms of the vascular responses to shear stress. Website Here

MD3: Medical Devices and Drug Delivery Lab [Blacksburg]

The MD3: Medical Devices and Drug Delivery Lab works in a highly multi-disciplinary environment to solve problems in cancer diagnosis and treatment through the combination of existing and emerging technologies. In our laboratory, we are interested in developing needle-based medical devices for cancer detection and treatment in real time. We are also interested in developing sustainable non-toxic nanopharmaceuticals that are designed and validated to be safe in the environment and in humans. Website here

Mechanics of Soft Biological Systems Lab [Blacksburg]:

The Mechanics of Soft Biological Systems Laboratory focuses on characterizing the mechanical properties of biological structures ranging from lipid bilayers to collagenous tissues in vertebrates and chitin-based tissues in invertebrates. The common theme of the lab is the study of the relationship between complex structures and mechanical behavior of biological system, using approaches that combine physically-sound theoretical models with novel experimental methods. website here.

Micro/NanoScale Biotic/Abiotic Systems Engineering (MicroNBASE) Laboratory [Blacksburg]

Our lab focuses on interfaces between biological and synthetic systems (or bio-hybrid-engineering). The research interests cover the study of micro-nano-robotics, nanotechnology, bio-nano interface, and biophysics of bacteria motility, chemotaxis and adhesion. There are two main broad categories of activities: (1) developing bio-hybrid engineered systems (biomicrobots) in which biological components are utilized for actuation, sensing, communication, and control. (2) studying mechanisms of adhesion, motility and sensing in cells or unicellular microorganisms. website here

Microfluidics Lab [Blacksburg]

Our research is concerned with the new science and technology generated by applying micro/nanofabricated structures and devices to biological studies and biosensors. One emphasis in our research is to develop high-throughput microfluidic tools to manipulate and analyze single cells and extract biological information. Another thrust in the group is on developing flow-through electroporation for efficient gene delivery into cells. Our ultimate goal is to apply this technique to create genetically modified cells for cancer immunotherapy, stem cell therapy and tissue regeneration. website here.

Nanostructured Biopolymer Engineering Lab [Blacksburg]

Biomaterials are an essential tool that provides the basis for bioengineered devices, growing and delivering cells, developing functional tissues, and engineering whole organs. Natural biopolymers that self-assemble on the nano scale have the potential to provide native cellular environments that facilitate the directed behavior of cells. Research conducted by the Nanostructured Biopolymer Engineering Lab makes use of naturally derived structural proteins for biomaterials development. Using primarily keratin proteins, Dr. Van Dyke's research group creates matrices and scaffolds used for tissue engineering and trauma applications, and studies their fundamental characteristics such as molecular self-assembly and structure-function relationships.

Occupational Ergonomics & Biomechanics Lab [Blacksburg]

The Occupational Ergonomics and Biomechanics Laboratory conducts work in theoretical and applied ergonomics, occupational biomechanics, and work physiology, primarily relating to work site, workstation, and equipment evaluation and design. Specifically, research is focused on biomechanics of the human body (modeling, strength, motions, and

working postures); human engineering of systems, equipment, tools, workstations and work tasks, and ergonomic design for safety, efficiency, and performance. [Website Here](#)

Orthopedic Mechanobiology Laboratory [Blacksburg]

Our research lab utilizes biomechanical, imaging and molecular biological approaches to study mechanisms of tendinopathy. Particular emphasis is placed on examining the therapeutic benefits of mechanical stimulation in tendon healing as well as understanding the roles of ADAMTS enzymes in aberrant extracellular matrix remodeling of skeletal tissues.

Quantitative Imaging Lab [Winston-Salem]

The focus of the Magnetic Resonance Quantitative Imaging Lab is to develop quantitative imaging techniques with magnetic resonance imaging to answer scientific questions and improve patient care. These imaging techniques are being used in numerous collaborative projects ranging from temperature mapping to evaluate new hyperthermia treatments with multiwalled carbon nanotubes, to measuring cerebral blood flow for improving patient care, to using phase contrast imaging to measure vascular stiffness. Traditional medical imaging has largely been qualitative, that is, the intensity of a pixel is arbitrary and only conveys relative information when comparing pixels. In contrast, the pixel intensities in quantitative images are directly proportional to a physical parameter (temperature, density, blood flow, velocity, concentration, etc.). This type of imaging provides repeatable, observer-independent measure of physical quantities.

Socha Lab: Comparative Biomechanics & Bio-Inspired Engineering [Blacksburg]

Our lab studies the biomechanics of motion in animals, conducting integrative research that crosses traditional boundaries of engineering and biology. Currently, two broad themes of our research center around gliding flight in vertebrates and internal fluid flows in invertebrates. We aim to understand animal movements both for fundamental understanding of animal physiology, ecology and evolution, and as inspiration for novel engineering applications. [website here.](#)

T. M. Murali Laboratory [Blacksburg]

The functioning of a living cell is governed by intricate networks of physical, functional, and regulatory interactions among different types of molecules. Recent experimental advances have yielded unprecedented insights into the structure of these interaction networks and into patterns of molecular activity (mRNA, proteins, and metabolites) in response to different conditions. The ultimate goal of my research is to build phenomenological and predictive models of these networks by developing approaches that investigate the relationships among the molecules in a cell, how these elements are organized into functional modules, how these modules interact with each other, and how different modules become activated or de-activated in various cell states.

[Website here.](#)

The Hall Lab: Basic and Applied Nanobiotechnology [Winston-Salem]

We are an interdisciplinary group of scientists using the tools of nanotechnology to study biology at the smallest scale. Our goals are to learn more about the basic functions and interactions of biological molecules and to use what we find to achieve new capabilities with biomedical implications. In pursuing this goal, we bring together aspects of physics, engineering, molecular biology, and many other disciplines. [Website here.](#)

Tissue Engineering Lab [Blacksburg]

The Tissue Engineering Laboratory explores methods for developing engineered bone and ligament tissues using a combination of novel biomaterials, adult stem cells, and advanced bioreactor technologies. Some specific issues being addressed include; elastomeric polyurethane biomaterials, electrospun fiber meshes with tunable mechanical and topographical properties, mechanotransduction and cell signaling in dynamic bioreactors, quantitative imaging of developing tissues, and fluid mechanics and mass transport. [Website Here](#)

VT MEMS Laboratory [Blacksburg]

Research at VT MEMS Lab currently centers on the development of three-dimensional micromachining techniques, micro gas analyzers for environmental and healthcare applications, biochips for cell analysis, cancer diagnosis, and cancer treatment monitoring, and biochips for pathogen detection in water. MEMS technology is used along with various microscopy techniques to determine mechanical and electrical signatures of cells under controlled microenvironments. Additional major thrust areas of research include micro analytical chemistry and micro/nano fabrication. [Website here](#)

Verbridge Laboratory for Integrative Tumor Ecology (LITE) [Blacksburg]

The LITE lab's main thrust is in using the tools of micro/nano technology and tissue engineering to study the role of cell-microenvironment interactions in cancer. One aim is to develop new engineering tools and in-vitro culture platforms to illuminate cellular response to microenvironmental cues (i.e. cell-cell, cell-matrix, chemical, electrical) and stresses (i.e. hypoxia, radiation, drug treatment) in a physiologically relevant 3-D context. [website here.](#)

Virginia Bioinformatics Institute (VBI) [Blacksburg]

VBI is a world-class research institute dedicated to the study of the biological sciences. by using bioinformatics and medical informatics, which combines transdisciplinary approaches to information technology and biomedicine, researchers at VBI create, interpret, and apply vast amounts of biological data generated from basic research to some of today's key challenges in the biomedical, environmental and agricultural sciences. The institute develops genomic, proteomic, and bioinformatic tools and databases to study genomes and diseases for the discovery of new vaccine, drug and diagnostic targets for humans and the species

upon which they depend to improve our quality of life, health and security. [website here](#)

Virginia Tech - Carilion Research Institute (VTCRI) [Roanoke]

Research conducted at the Virginia Tech Carilion Research Institute (VTCRI) creates a bridge between basic science research at Virginia Tech and clinical expertise at Carilion Clinic and increases translational research opportunities for both partners. Research conducted by scientists at the institute is aimed at understanding the molecular basis for health and disease, and development of diagnostic tools, treatments, and therapies that will contribute to the prevention and solution of existing and emerging problems in contemporary medicine. Research areas of emphasis which presently align with areas of strength and active research at Virginia Tech include inflammation, infectious disease, neuroscience, and cardiovascular science and cardiology. [website here.](#)

WFSM Orthopedic Surgery Lab [Winston-Salem]

Orthopedic Surgery has numerous collaborative research projects with SBES faculty in many areas including: Hand/Upper Extremity/Microsurgery Sports Medicine Orthopedic Trauma and Foot & Ankle Surgery Total Joint Arthroplasty, Adult Reconstruction and Joint Preservation Surgery (Hip and Knee)

Wake Forest Institute for Regenerative Medicine (WFIRM) [Winston-Salem]

Ever since the first engineered skin tissue was transplanted in 1981, the potential of regenerative medicine has captured the imagination of physicians and scientists worldwide. Technologies for engineering tissues are developing rapidly, with the ultimate goal of delivering new therapies into patients as safely and efficiently as possible. Our current research focuses on a wide range of engineered tissues with the aim of making a lasting impact on conditions ranging from diabetes to heart disease. In addition, we're working to apply the science of regenerative medicine to battlefield injuries and are working to help solve the shortage of donated organs available for transplant. As a result of our preliminary successes, tissue engineering and cellular therapy programs now span multiple organ systems. [Website Here](#)

X-Ray Systems Lab [Blacksburg]

The X-ray Systems Lab aims at developing novel medical imaging technologies for biomedical and bioscientific discovery, radiological diagnosis, and medical intervention. Directed by Dr. Guohua Cao, the lab focuses on novel x-ray sources, detectors, and system engineering. Our research activities are interdisciplinary and translational, and interface between basic sciences, translational development, and clinical applications. [website here.](#)

DEGREES OFFERED

PhD Degree

Offered In (Blacksburg, Roanoke, Wake Forest)

GRE

General Test: Verbal, Quantitative, Analytical Writing, Combined (310.0)

GRE COMBINED (V & Q): Minimum "New" Combined score (310.0)
TOEFL

Paper: (600.0)

iBT: (100.0)

IELTS

IELTS: Band: (7.0)

The Ph.D. degree requires a minimum of 90 total credit hours beyond the baccalaureate. Additionally, a dissertation must be written and defended before a 5-person committee. The Ph.D. plan of study is due by the end of the third semester of study registered as a Ph.D. student. All coursework must be 5000-level and above (VT campus) and 600-level and above (WFU campus). The distribution of required hours can be: 40 - 55 credit hours of research (7994-level only, VT) 35 - 50 course credits Specific course of study requirements are as follows: Course Requirements for BME Ph.D. Program: The Doctor of Philosophy degree in Biomedical Engineering must include the following minimum requirements: 15 credits of engineering courses (BMES or from any engineering department) to include the required courses, Quantitative Cell Physiology and Quantitative Organ Systems Physiology. 6 credits of graduate level mathematics, only 3 of which may be in statistics (see approved lists on website for each campus location) 3 credits of life science coursework from approved courses and/or departments on each campus (see website/handbook for details) 2 credits from the required BMES 6064 Clinical Rotation (available only to PhD candidates) 9-24 credits in elective coursework, remainder of hours up to 90 in research Ph.D. students must complete training in Ethics, required by the graduate schools, which must be noted on the plan of study. See the SBES Graduate Handbook for details regarding implementation on each campus. Students are also required to enroll in and successfully complete the SBES Seminar course (BMES 5944 at VT and BMES 694 at WFU) each semester of all the academic years during their degree program. Ph.D. students must pass a Qualifying Exam no later than the end of the second year for students entering directly into the Ph.D. program or within one year of entering the program after completing the M.S. degree. ALL students are expected to participate in the annual Research Symposium held each spring, and are required to do an oral research presentation at least once before they graduate. Ph.D. students may elect to earn an M.S. degree as an intermediate milestone to the Ph.D. with the prior approval of their advisor. They must file an M.S. plan of study at the end of the second semester of study, and write and defend a thesis. Please refer to www.beam.vt.edu for details regarding all degree requirements.

Degree Concentrations:

MS Degree

Offered In (Blacksburg, Roanoke, Wake Forest)

GRE

General: Verbal, Quantitative, Analytical, Combined Q&V (310.0)

Combined Q&V: Combined Q&V (310.0)

TOEFL

Paper: (600.0)

iBT: (100.0)

IELTS

IELTS: Band (7.0)

The Master of Science degree requires a minimum of 30 total credit hours beyond the baccalaureate which must consist of: 6 - 9 credit hours of research (5994-level only, VT) 21 - 24 course credits Specific course of study requirements are as follows: Course Requirements for BME M.S. Program: The M.S. degree in Biomedical Engineering must include the following minimum requirements: 9 credits of engineering courses (BMES or from any engineering department) to include the required courses, Quantitative Cell Physiology and Quantitative Organ Systems Physiology. 3 credits of graduate level mathematics which can be either pure math or statistics from approved lists on each campus (see website) 3 credits of life science from approved courses and/or departments on both campuses (see website/handbook for details) 6 - 9 credits in elective courses, the remainder up to 30 in research All coursework must be at the 5000-level or higher (Blacksburg) and 600-level or higher (Wake Forest). M.S. students must also enroll in and successfully complete the SBES Seminar course (BMES 5944 at VT and BMES 694 at WFU) each semester of all the academic years during their degree program. M.S. students must complete training in Ethics, required by the graduate schools, which must be noted on the plan of study. See the SBES Graduate Handbook for details regarding implementation on each campus. A written plan of study is to be submitted at the end of two semesters of graduate study. All M.S. students write and defend a thesis. There is no non-thesis M.S. degree in SBES. ALL students are expected to participate in the annual SBES Research Symposium held each spring, and are required to do an oral research presentation at least once before they graduate.

GRADUATE COURSES (BMES)

BMES 5024 (BMVS 5224):

Biomedical Engineering and Human Disease

Comprehensive overview of a variety of human diseases, including, neurological disorders, cardiovascular disease, infectious disease, and cancer, designed primarily for graduate students majoring in engineering and other related areas who have a long-term academic and professional goal in the field of biomedical engineering and life sciences. Introduction to state-of-the-art biomedical engineering approaches used for the study of early detection/diagnosis, treatment and prevention of human disease. Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

BMES 5044 (BSE 5044) (CHE 5044):

Engineering Mathematics

Introduction to numerical solutions of partial differential equations using the finite element method in one-, two-, and three-dimensions with direct relevance to chemical engineering, biological systems engineering and biomedical engineering and sciences. Partial differential equations and ordinary differential equations using finite differences, model parameter sensitivity analysis, optimization, and data analysis. Pre-requisite:

Graduate Standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

BMES 5054:

Quantitative Cell Physiology

Mathematical modeling, simulation, quantitative description of cell physiology and control. Numerical simulation of cellular physiologic processes including reaction kinetics, inhibition and cooperativity, passive transport, facilitated and carrier-mediate reaction kinetics. Cell resting membrane potential, and nerve and muscle tissue. Modeling of neural cell processes including voltage-gated channels, neurotransmitter kinetics, and postsynaptic cell membrane potentials.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s): BMES 5044

BMES 5064:

Quantitative Organ Systems Physiology

Mathematical modeling, simulation, quantitative description of organ physiology and control. Numerical simulation of cardiovascular physiologic processes including regulation of cardiac output, the baroreceptor - stroke volume model, venous return, and closed-loop control. Respiratory ventilation mechanics, gas exchange, pulmonary circulation, alveolar-capillary diffusion, and respiratory ventilation control. Nephron countercurrent mechanism and hemodialysis. Modeling of endocrine system functions.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s): BMES 5044

BMES 5124 (ESM 5224):**Advanced Musculoskeletal Biomechanics**

Skeletal anatomy and mechanics. Muscle anatomy and mechanics. Theory and application of electromyography. Motion and force measuring equipment and techniques. Inverse dynamics modeling of the human body. Current topics in musculoskeletal biomechanics research.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

BMES 5154G:**Advanced Commercialization of Biomedical Engineering Research**

Commercialization process applied to translational research. Regulatory aspects of biomedical engineering products and technologies (e.g. devices, diagnostics, drugs, biologics). Intellectual property, technology transfer processes, clinical trial design, commercialization of university research, modeling of development costs (e.g. cash flow and revenue projections). Small business startup approaches. Pre: Graduate Standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

BMES 5164:**Advanced Impact Biomechanics**

A review of impact biomechanics and critical investigation of the impact response of the human body. Participants will study the dynamic response of the head, neck, chest, abdomen, upper extremities, and lower extremities. Real world examples from automobile safety, military applications, and sport biomechanics.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): (ME 3504 (UG), ME 3614 (UG)) OR (ESM 3054 (UG), ESM 3124 (UG)) OR (ME 3504, ME 3614) OR (ESM 3054, ESM 3124)

Corequisite(s):

BMES 5174 (ME 5174):**Biomechanics of Crash Injury Prevention**

Principles of design and analysis of crash injury prevention methods in vehicle crashes. The course encompasses three major focus areas for occupant protection in crashes: crash energy absorption in (1) the vehicle structure, (2) the occupant, and (3) the occupant restraints.

Topics include the biomechanics of impact injury, analysis of occupant response in crash tests, vehicle crash kinematics, modeling of vehicle impact response, modeling of human impact response, and occupant restraint design. Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

BMES 5184:**Injury Physiology**

Introduction to the physiology of injury. Focus on the pathophysiology, mechanisms, and outcomes of injury in humans. Explores injury physiology at the organ, tissue, and cellular level. Topics include physiology of injury to the peripheral and central nervous systems, the musculoskeletal system, the pulmonary system, the abdomen, and the eye. Includes the injury physiology of adults as well as the special populations of children, pregnant females, and the elderly. Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s): BMES 5054

BMES 5204 (ME 5204):**Laboratory Techniques in Injury Prevention**

Human surrogate biomechanical impact testing. 3-D rigid-body kinematics, kinetics, properties of deformable materials, servosled testing. Injury prediction and mitigation for transport systems.

Transportation restraint system design. Instrumentation, data acquisition, and signal processing techniques of impact biomechanics. Pre: Graduate standing.

Credit Hour(s): 4

Lecture Hour(s): 4

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

BMES 5214 (ISE 5614):**Human Physical Capabilities**

Focuses on the modeling, analysis, and evaluation of industrial workplaces with emphasis on the physical demands placed on and the capabilities of workers. Topics covered include: physiology, anthropometry, bioinstrumentation, and biomechanics. Students will learn and apply a range of contemporary analytical and assessment methods. Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

BMES 5304 (CHE 5304):**Biological Transport Phenomena**

The fundamental principles of mass transport phenomena will be introduced and applied to the characterization of transport behavior in biological systems (e.g., cell, tissues, organs, people). Topics will include active, passive, and convective molecular transport mechanisms. These fundamentals will be used to develop analytical and predictive models that describe phenomena such as oxygen transport, kidney function, systemic drug delivery, and design of extracorporeal devices. Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): CHE 3114 (UG) OR CHE 3114, (CHE 3044 (UG) OR CHE 3044 OR CHE 3144 (UG) OR CHE 3144) OR (ME 3304 (UG) OR ME 3304, ME 3404 (UG) OR ME 3404)

Corequisite(s):

BMES 5304G:**Advanced Biological Transport Phenomena**

Engineering analysis and predictive modeling of heat and mass transport in biological systems (e.g., tissues, organs, organisms, and biomedical devices). Examination of processes that involve conduction, convection, diffusion, generation/ consumption. Application of analytical and computational methods to solve differential equations that describe unsteady and/or multi-dimensional transport. Topics include oxygen transport, drug delivery, pharmacokinetic analysis, kidney function, blood perfusion, cryopreservation, and hyperthermia. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

BMES 5305 (ESM 5305):**Biomechanics of the Cardiovascular System**

5305: Mechanics of the heart, arterial blood vessels and microcirculation; history of the circulation; anatomy and physiology of the heart; mechanics of cardiac contraction; cardiac fluid mechanics; work, energy, efficiency of cardiac function. 5306: Rheology of blood; hematology; elasticity of blood vessel walls; transport processes; control of the circulation; mathematical analysis of pulsatile blood flow and pulse-wave propagation through small arteries, capillary beds and extra-corporeal devices.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

BMES 5306:**Biomechanics of the Cardiovascular System**

5305: Mechanics of the heart, arterial blood vessels and microcirculation; history of the circulation; anatomy and physiology of the heart; mechanics of cardiac contraction; cardiac fluid mechanics; work, energy, efficiency of cardiac function. 5306: Rheology of blood; hematology; elasticity of blood vessel walls; transport processes; control of the circulation; mathematical analysis of pulsatile blood flow and pulse-wave propagation through small arteries, capillary beds and extra-corporeal devices.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

BMES 5314:**Introduction to Regenerative Medicine**

Current state of the field of regenerative medicine with specific emphasis on the technological challenges that limit the efficacy and clinical translation of engineered tissues and therapies. Life science (e.g., cell biology, organ physiology, biochemical methods) and engineering perspectives (e.g., stem cells, biologically-inspired materials, gene therapies) Prerequisite: Graduate Standing required

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

BMES 5324:

Advanced Topics in Regenerative Medicine

Advances in regenerative medicine, gene therapy, stem cell biology/therapy, biomaterials, tissue engineering, and the physiology of the major organ systems in both health and disease. Problem solving novel approaches to overcome limitations to engineer anatomically accurate and fully functional organ replacements to solve the unmet clinical need for donor organs.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): BMES 5314

Corequisite(s):

BMES 5434:

Polymeric Biomaterials

Topics include polymer design and processing, inflammatory responses to polymers, interaction of blood with polymeric materials, and the effect of mechanical, chemical, and surface properties of polymers on cells. The culmination of this course will provide students with the knowledge to successfully design polymer-based biomaterials, drug-delivery devices, and bio-implants. Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

BMES 5514 (ME 5714):

Digital Signal Processing for Mechanical Measurements

The fundamentals of digital signal processing of data experimentally obtained from mechanical systems will be covered. Attention will be given to the data acquisition, A/D conversion, aliasing, anti-aliasing filtering, sampling rates, valid frequency ranges, windowing functions, leakage, and various transform methods. Special attention will be given to random, transient, and harmonic function data processing. Various methods of estimation of the frequency response function (FRF) will be explored. The estimation methods will be assessed as to their impact on FRF estimation errors.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

BMES 5525 (ECE 5605):

Stochastic Signals and Systems

Engineering applications of probability theory, random variables and random processes. Time and frequency response of linear systems to random inputs using both classical transform and modern state space techniques.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): STAT 4714 (UG) OR STAT 4714

Corequisite(s):

BMES 5534:

Advanced Computational Methods and Modeling for Biomedical Applications

Methods of biomedical computational model development, solutions of ordinary and partial differential equations in mathematical models for biomedical applications, and current topics in biomedical modeling. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

BMES 5574:

Advanced Biomaterials

Materials for medical applications. Basic material types and properties, functional uses of materials in medical applications, and tissue response mechanisms. Integrated design issues of multicomponent material design in prosthetic devices for hard and soft tissues, orthopedics, cardiovascular, and drug delivery applications. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

Corequisite(s):

BMES 5614:

Multiscale Cancer Engineering

A multidisciplinary, multiscale approach to analyzing cancer etiology, progression, detection, and therapy. Traditional and emerging methods of analyzing biomolecular aspects of cancer. Tumor microenvironment modeling and analysis. Physical oncology-inspired cancer therapy.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): BMES 5044

Corequisite(s):

BMES 5714:

Biomedical Microdevices

The goal of this course is to build the foundation necessary for engineering research in micro- and nano- biotechnology. The course will be broken down into four major area: micro- and nano- fabrication techniques, the fundamentals of microfluidics, micro- and nano- particle manipulation, and engineering aspects of cells and their membranes.

The culmination of the course will provide students the knowledge required to create biomedical micro- and nano- devices with a focus on the unique physics, biology and design aspects at these scales.

Students will be expected to know undergraduate engineering, physics, and calculus. Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

BMES 5724:

Biomedical Nanoengineering

Major concepts in the design, production, and utility of micro- and nanotechnologies in biomedicine. Critical instrumentation, strategies for fabrication at the micro- and nanoscale, relevant nanoscale materials, engineering principles, and practical applications to biomedicine.

Designed primarily for graduates who have a long-term academic and professional goals in the fields of biomedical engineering and biotechnology. Pre: Graduate Standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

BMES 5764 (ME 5764):

Modeling MEMS and NEMS

Modeling MEMS and NEMS is about the construction, analysis, and interpretation of mathematical and computational models microelectromechanical and nanoelectromechanical systems (MEMS and NEMS). A goal throughout the course will be to develop a physical intuition for the fundamental phenomena at these small scales. The material covered will be broad and multidisciplinary including: dimensional analysis and scaling; a review of continuum mechanics; fluid dynamics, elasticity, thermal transport and electromagnetism at the micro and nanoscales; the modeling of a variety of new MEMS/NEMS devices; and approaches beyond the continuum theory including stochastic and deterministic methods. Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

BMES 5944:

Seminar

NONE

Credit Hour(s): 1

Lecture Hour(s): 1

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

BMES 5974:

Independent Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Independent Study

Instruction Type(s): Independent Study

Prerequisite(s):

Corequisite(s):

BMES 5984:

Special Study

NONE

Credit Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

BMES 5994:

Research and Thesis

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research

Instruction Type(s): Research

Prerequisite(s):

Corequisite(s):

BMES 6064:

Clinical Rotation

The course gives the student both a broad view of the use of engineering principles in medicine and general clinical care, together with an in-depth study of a particular aspect of medicine under the direct supervision of a physician. The student is allowed to observe the operation and maintenance of various clinical modalities, systems, and devices under the guidance of a working engineer or technician. The student participates in clinical rounds and image reading sessions to gain insight into the actual operation and needs of departments using medical imaging modalities. Pre: BME Ph.D. graduate students who have finished first year of study.

Credit Hour(s): 2

Lecture Hour(s):

Instruction Type(s): Lab

Instruction Type(s): Lab

Prerequisite(s):

Corequisite(s):

BMES 6164:

Computational Modeling in Impact Biomechanics

Dynamic modeling of the human body subjected to transient impact loading. A combination of finite element analysis and multi-body simulated techniques. Utilized software packages with dynamic solvers. Applications include computer-aided design for automobile safety, sports biomechanics, and military restraint systems.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): (BMES 5164 (UG) OR ME 5754 (UG)) OR (BMES 5164 OR ME 5754)

Corequisite(s):

BMES 6174:

Advanced Human Modeling: Injury and Tissue Biomechanics

Serves as a continuation of Impact biomechanics (BMES 5164) and computational biomechanics (BMES 6164), which uses Madymo. Basics of the finite element method as it applies to high-rate phenomena. Focus will be on practical problems and the use of commercial codes for solving vehicle crashworthiness and biomechanics problems. Theory will be presented when it is useful for application to the problem. Real world examples from biomedical engineering, automobile safety, military applications, and sport biomechanics are used.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): (BMES 5164 OR ME 5754), (BMES 6164 OR ME 6754)

Corequisite(s):

BMES 6194:

Advanced Movement Assessment

This course will expand on previous course work and provide a detailed understanding of the methods used to collect human movement data, how to process data and interpretation of data output for the assessment of human movement. This course will also evaluate current literature in the area of human biomechanics and the application of these techniques in research and clinical settings.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): BMES 5124 OR ESM 5224

Corequisite(s):

BMES 6524:

Physics of Medical Imaging

Physical principles, mathematical algorithms and devices used in diagnostic medical imaging. Medical imaging modalities and digital imaging; computerized tomography and reconstruction algorithms; ultrasound imaging; magnetic resonance imaging; nuclear medicine imaging; patient safety and applications. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s): null null

BMES 6534:

Medical Health Physics

Physical and biological aspects for the assessment of and protection from ionizing radiation in medical environments. Biological consequences of human radiation exposure. Principles of ionizing radiation protection. Radiation exposure recommendations and regulations. Radiation shielding, design, personnel monitoring, and medical health physics instrumentation.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): BMES 6544

Corequisite(s):

BMES 6544:

Radiological Physics

Nature and fundamental concepts of ionizing radiation. Radiological principles, radiation interactions, production of radiation and radiation dosimetry. Radiation quantities, attenuation and stopping power, charged particle and radiation equilibria and radioactive decay. Photon interactions, charged and uncharged particle interactions, x-ray production and quality and dosimetry concepts. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

BMES 6554:

Radiation Therapy Physics

The physics of radiation therapy through the use of radiation producing equipment, character of photon and electron radiation beams, radiation dose functions, computerized radiation treatment planning, brachytherapy, special radiation treatment procedures, quality assurance, and radiation shielding for high energy facilities.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): BMES 6544

Corequisite(s):

BMES 6984:

Special Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

BMES 7994:

Research and Dissertation

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research, Online Research

Instruction Type(s): Research, Online Research

Prerequisite(s):

Corequisite(s):

GENETICS, BIOINFORMATICS, AND COMPUTATIONAL BIOLOGY

Liwu Li, Program Director

Professors: Daniela Cimini; Glenda Gillaspay; Elizabeth Grabau; Ruth Grene; Lenwood Heath; Ina Hoeschele; T Murali; Christopher North; Mohammad Saghai-Marouf; Adrian Sandu; Clifford Shaffer; Edward Smith; Zhijian Tu; John Tyson; Richard Veilleux; Layne Watson;

Associate Professors: Young Cao; Richard Helm; John Jeleško; Christopher Lawrence; Song Li; Biswarup Mukhopadhyay; Michelle Olsen; Alexey Onufriev; Ryan Senger; Igor Sharakhov; Boris Vinatzer; Hehuang Xie; Liqing Zhang; Jinsong Zhu;

Assistant Professors: Jing Chen; Silke Hauf; Jason Holliday; Kate Langwig; Maria Lazar; William Mather; Gota Morota; Florian Schubot; Sujith Vijayan; Mark Williams;

Research Assistant Professors: Fernando Biase;

Graduate Contact: dennie@vt.edu

GBCB Home Page: <https://gbcg.graduateschool.vt.edu/>

The research paradigm exemplified by the Human Genome Project requires an academic training paradigm that creates team-oriented researchers who may be specialists in one area but who are literate in several other disciplines. For example, researchers with expertise in the mathematical, statistical, or computer sciences also require sufficient knowledge in biology to understand the questions in order to develop appropriate analytical methods and computer tools. Similarly, life scientists need sufficient grounding in mathematics, statistics and

computer science to be educated users of these quantitative methods and tools, and to conceptualize new tools. Research and training environments that produce such a combination of skills are not commonly found in academia. Our program is designed to provide that training environment in genetics/genomics, bioinformatics, and computational biology. This program will allow Ph.D. students to conduct original research in the areas of genetics, bioinformatics, and computational biology. This training will enable graduates of the program to pursue careers in academia, government, or the private sector. This will be achieved through a combination of discipline-specific and cross-disciplinary course work, as well as a multidisciplinary research environment maintained by program faculty and distinguished by a high level of collaboration between disciplines. The scientific and training focus of the program is on three interdependent areas which have emerged as significant in the post-genomic era: experimental approaches and technologies for addressing complex biological questions, methods for collection, management and analysis of large biological data sets, and data-based modeling of biological systems.

SPECIAL FACILITIES

These are some of the many buildings housing several labs that GBCB students and faculty work in: Fralin Life Sciences Institute (FLSI), Torgersen Hall, Derring Hall, Life Sciences Building I (LSI), Latham Hall, McBryde Hall, Fralin Hall, Engel Hall, Seitz Hall, Price Hall and many others across campus due to the breadth of our program.

Genetics, Bioinformatics, and Computational Biology

Several facilities are shared across campus due to the breadth of our program: Some of the buildings are Derring Hall, Latham Hall, Life Sciences 1 Building, McBryde Hall, Price Hall, Steger Hall, Torgersen Hall

Genetics, Bioinformatics, and Computational Biology

Several facilities are shared across campus due to the breadth of our program. Some of the buildings are Torgersen Hall, McBryde Hall, VBI, Latham Hall, Derring Hall, Life Sciences 1 Building, Price Hall, etc.

DEGREES OFFERED

PhD Degree

Offered In (Blacksburg)

TOEFL

Paper: (600.0)

Computer: (213.0)

iBT: (80.0)

GRE

General Test: Verbal (300.0), Quantitative (700.0), Analytical (3.0)

GBCB is a Ph.D. program only, it does not offer a Master's degree. The Ph.D. degree requires a minimum of 90 total credit hours beyond the baccalaureate. Additionally, a dissertation must be written and defended before a 4-person committee. The Ph.D. plan of study is due by the end of the fourth semester of study. The distribution of the 90 required hours can be: 30-63 credit hours of research (7994 level only) 27-60 graded coursework (graduate level) For the purposes of this program and to insure that students have a breadth of exposure, four specialty tracks

are defined: LIFE SCIENCES, COMPUTER SCIENCE, STATISTICS, and MATHEMATICS A student will select one of the specialty tracks as his/her primary track, which will typically be consistent with the student's undergraduate training. The other tracks will be denoted as secondary tracks. Requirements will differ among the specialty tracks, with some requiring more coursework, and with correspondingly fewer credit hours of Research and Dissertation. In addition, a core curriculum that is common to all students has been defined: GBCB 5874 Problem Solving (3 credits) STS 5444 Issues in Bioethics (3 credits) GBCB 5004 Seminar (4 credits) A sample plan of study will include the following: Primary Track: At least 9 credit hours must be from the primary track. For students whose primary track is the Life Science track, 3 of these credit hrs must be a genomics course. Several genomics courses are offered through different departments. (e.g., CSES/GBCB 5844 - Plant Genomics) Secondary Tracks: At least 12 credit hours must be taken, with the courses coming from at least two of the three secondary tracks. For students whose primary track is not in Life Sciences, at least 6 of these credit hrs must be in the life sciences track. Students in the Statistics primary track must take a genomics course. General Electives: Choice of at least 6 credit hrs of electives Research & Dissertation: Sufficient to accumulate 90 total credit hours, minimum of 30 hours required. Examinations: All GBCB students must pass a preliminary and a final exam. The preliminary exam, oral and written, is conducted by the student's advisory committee. Between the third and fourth years, each student must prepare a dissertation research plan and give an oral defense of that plan and the scientific foundations on which it is based. The dissertation research plan is expected to be a refinement of the initial research plan presented by the student to his committee at the end of the second year. The proposal is to be prepared in an NIH-style format and should provide a clearly defined description of the research the student plans to complete. The oral defense of the plan will include questions both directly related to the proposal as well as more general questions that examine the student's knowledge of fundamental principles. The student may be tested on any aspect of his proposal, the philosophy of science, and research methodology. It is recommended that the student meet with his/her advisory committee prior to preparing for the exam to discuss the nature of the exam and evaluation procedures. The final exam, oral and written, is primarily a defense of the dissertation, but other areas of science may be included.

GRADUATE COURSES (GBCB)

GBCB 5004:

Seminar in Genetics, Bioinformatics, and Computational Biology

Review and discussion of current topics and literature in genetics, bioinformatics, and computational biology by students, Virginia Tech faculty, and outside speakers. Students give formal presentations of research results or current literature. May be repeated. Pre: graduate status in the Program in Genetics, Bioinformatics, and Computational Biology or in a department that offers the Bioinformatics Option.

Credit Hour(s): 1

Lecture Hour(s): 1

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

GBCB 5314 (PPWS 5314):**Biological Paradigms for Bioinformatics**

This course is an intensive introduction to the central paradigms of molecular cell biology for bioinformatics. Material from cell molecular biology, and genetics will be presented, and placed in a genomics context. The course prepares students in mathematical disciplines to interact in teams in the pursuit of bioinformatics research. Pre: Senior or graduate standing in mathematically-based disciplines such as computer science, statistics, mathematics or engineering.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

GBCB 5424 (BIOL 5424) (CS 5424):**Computational Cell Biology**

Use of mathematical models (nonlinear ordinary differential equations and stochastic processes) and simulation algorithms to explore complex feedback circuits that control the behavior of living cells. Concepts and techniques from dynamical systems theory, bifurcation analysis, numerical methods, SBML (systems biology markup language) and Matlab programming. Applications in gene regulatory networks, cell cycle control, circadian rhythms, cell signaling.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): MATH 5515

Corequisite(s):

GBCB 5515 (MATH 5515):**Mathematical Methods for Modeling and Simulation of Biological Systems**

Introduction to mathematical techniques for modeling and simulation, parameter identification and analysis of biological systems. Emphasis on both theoretical and practical issues and methods of computation, with concrete applications. Suitable for students from the mathematical and life sciences who have a basic foundation in multivariate calculus and ordinary differential equations. 5515: Continuous models and methods. 5516: Discrete models and methods.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

GBCB 5874:**Problem Solving in Genetics, Bioinformatics, and Computational Biology**

Research practicum in genetics, bioinformatics, and computational biology. Emphasis on the multidisciplinary and collaborative nature of research in genetics, bioinformatics, and computational biology. Exposure to the scientific method, the nature of research tools, strategies for publishing, and opportunities for research careers in genetics, bioinformatics, and computational biology. Permission required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

GBCB 5974:**Independent Study**

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Independent Study

Instruction Type(s): Independent Study

Prerequisite(s):

Corequisite(s):

GBCB 5984:**Special Study**

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 9

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

GBCB 7994:**Research and Dissertation**

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research

82 Instruction Type(s): Research

Prerequisite(s):

Corequisite(s):

INFORMATION TECHNOLOGY

Parviz Ghandforoush, Head

Professors: Ralph Badinelli; France Belanger; Ing Ray Chen; Stephen Edwards;

Parviz Ghandforoush; Devi Gnyawali; Scott Midkiff; Cliff Ragsdale; Narendran Ramakrishnan; Steven Sheetz; Joseph Tront;

Associate Professors: Wade Baker; Donald Hatfield; Barbara Hoopes; Lara Khansa; Raymond Major; Linda Tegarden; Yaling Yang;

Assistant Professors: David Townsend;

Affiliated Faculty: Randolph Marchany; Robert Pettit; David Raymond;

Bank of America Professor: Cliff Ragsdale;

R. B. Pamplin Professor: Devi Gnyawali;

PricewaterhouseCoopers Senior Faculty Fellow of ACIS: Steven Sheetz;

Ralph Medinger Lenz Professor: Ralph Badinelli;

R. B. Pamplin Professor and Tom & Daisy Byrd Senior Faculty Fellow: France Belanger;

Professor of Practice: David Simpson;

Assistant Professor of Practice: Kendall Giles; Gregory Kulczycki;

General Contact: vtmit@vt.edu

Graduate Contact: gmoses@vt.edu

Graduate Site: <http://www.vtmit.vt.edu>

Virginia Tech's Master of Information Technology program is a fully online, interdisciplinary graduate degree program offered collaboratively by Virginia Tech's College of Engineering and the Pamplin College of Business. The program is asynchronous and designed for working professionals wanting to study in the rapidly expanding and evolving areas of information technology including cybersecurity, artificial intelligence, data analytics, software development and electronic networks. Students may pursue the full 33-credit master's degree or enroll in one of six graduate certificate programs: Business Analytics and Data Mining Database Management Information Security and Analytics Information Technology Management Health Information Technology Software Development.

SPECIAL FACILITIES

The master's degree program in Information Technology is only offered in an online format. Students may take courses online from any location around the country and the world. There are no residency requirements.

Virtual

The Master of Information Technology program is offered online as a fully asynchronous degree. Students may take courses online from any location around the country and the world. There are no residency requirements.

DEGREES OFFERED

MIT Degree

Offered In (Virtual)

TOEFL

Computer: (90.0)

IELTS: (6.5)

Thirty-three credits are required for the Master of Information Technology degree. Each student must complete four of six offered core courses, and seven elective courses. Students are encouraged to focus elective study in areas of interest called modules: Analytics and Business Intelligence, Big Data, Business Information Systems, Cybersecurity, Cybersecurity Management, Cybersecurity Policy, Decision Support Systems, Health Information Technology, Networking, Software Engineering, and Software Development. The core courses include Fundamentals of Computer Systems, Information Systems Design & Database Concepts, Object-Oriented Programming with Java, Software Engineering, Strategic Leadership in Technology-Based Organizations, and Web-based Applications and E-Commerce. Graduate Certificates are offered in Business Analytics and Data Mining, Database Management, Information Security and Analytics, Health Information Technology, Software Development, and Information Technology Management.

MACROMOLECULAR SCIENCE AND ENGINEERING

Abby Whittington, Program Director

Emeriti Faculty: John Dillard;

Professors: Donald Baird; Romesh Batra; Scott Case; Richey Davis; David Dillard; Kevin Edgar; Alan Esker; Charles Frazier; Harry Gibson; Barry Goodell; James Heflin; Matthew Hull; Erdogan Kiran; John Lesko; Timothy Long; Roop Mahajan; Herve Marand; Steven McKnight; Robert Moore; Padmavathy Rajagopalan; Sam Turner; Joseph Wheeler; Christopher Williams; Michael von Spakovsky;

Associate Professors: Marwan Al-Haik; Justin Barone; Bahareh Behkam; Paul Deck; Michael Ellis; Aaron Goldstein; Louis Madsen; Stephen Martin; John Matson; Amanda Morris; Amrinder Nain; Maren Roman; Diego Troya; Abby Whittington;

Assistant Professors: Irving Allen; Shengfeng Cheng; Deborah Kelly; Guoliang Liu; Frederick Michel; Vinh Nguyen; Gary Seidel; Chenggang Tao; Scott Verbridge;

Alexander Giacco Professor of Chemical Engineering: Donald Baird;

Adhesive and Sealant Science Professor: David Dillard;

Thomas M. Brooks Professor of Wood Science and Forest Products: Charles Frazier;

Clifton C. Garvin Professor of Biomedical Engineering and Mechanics: Romesh Batra;

Lewis E. Hester Chair Professor and Director of the Institute for Critical

General Contact: mii@vt.edu

Graduate Site: <http://mii.vt.edu>

The Macromolecular Science and Engineering (MACR) graduate programs are interdepartmental, intercollegiate M.S. and Ph.D. degrees focused on polymer science and engineering. The programs are interdisciplinary in nature with faculty members from the Colleges of Science, Engineering, and Natural Resources. Students work under the direction of faculty in the departments of Chemistry, Physics, Sustainable Biomaterials, Chemical Engineering, Materials Science Engineering, Mechanical Engineering, Engineering Science and Mechanics, and Civil Engineering. Students working under the direction of these faculty may pursue the departmental curricula or the Macromolecular Science and Engineering curriculum to earn degrees in the respective programs. The MACR curriculum is designed to offer the flexibility needed to tailor interdisciplinary programs of study to emerging areas related to polymeric materials. Students may choose from four fundamental modules (Synthesis, Structure, Processing, or Mechanics of Polymers) or from a series of emerging technological domains (Polymers in Materials Medicine, Adhesion and Interfaces, Opto- and Micro-electronics, or Composites) to build technical depth. Breadth is gained through polymer courses outside the concentration area, as well as through elective coursework and research. In addition to the technical courses, the program emphasizes the development of technical oral and written communication skills, team building and leadership skills, and the option to build awareness of business practices in the polymer industries through a targeted course in this area.

SPECIAL FACILITIES

Facilities include laboratories in the ICTAS II building, Hahn Hall, and Goodwin Hall.

Macromolecular Materials Discovery Center of the Macromolecules Innovation Institute (MMDC)

The Macromolecular Materials Discover Center (MMDC) is a state-of-the-art materials characterization laboratory associated with the Macromolecules Innovation Institute (MII). The MMDC is a shared user facility that accelerates discover by providing MII-affiliated students, faculty, and industrial partners' access to specialized instrumentation that might be impactful for a single research group or company to purchase on their own. Facility users can collect detailed information on mechanical, thermal, and other properties of the novel materials they create, expanding the scope of their research and the potential applications for their products. Hands-on training allows students to be directly involved in sample prep, testing, and analysis, enhancing fundamental understanding and facilitating seamless collaboration. Under the MMDC business model, continuous acquisition of new instrumentation to meet researchers' needs will help ensure that, at Virginia Tech, instrumentation access won't be a barrier to breaking new boundaries in materials science. Macromolecular Materials Discovery Center 265 ICTAS II1075 Life Science CircleBlacksburg, VA 24061

DEGREES OFFERED

MS Degree

Offered In (Blacksburg)

TOEFL

Computer: (213.0)

iBT: (80.0)

Paper: (550.0)

GRE

General Test: Verbal, Quantitative, Analytical

Master's (M.S.) * MACR 5015/5016: Macromolecular Fundamentals with Laboratory I/II (3 cr) (sample 5015 syllabus, sample 5016 syllabus)* CHEM/CHE 5014 : Technical Oral Communications and Presentation Methods (1 cr.) (sample syllabus)* MACR 5024: Writing Skills for Macromolecular Science and Engineering (1 cr.) (sample syllabus)* Technical Concentration Area (6 cr. from one program module)* MACR Elective Courses (4 cr. from any remaining program modules)* MACR 5994: Research and Dissertation (minimum of 10 cr.)Total Program Hours: 32Advancement to Candidacy Requirements (M.S.)* By the end of the 2nd academic semester in residence, the student will submit an approved Plan of Study and 1st evaluation after meeting with their major professor.* By the end of the 4th academic semester in residence, the student is expected to meet with their committee and submit a 2nd evaluation.* At least once per year thereafter, the student is expected to submit an annual evaluation until the student is ready to defend his/her thesis.

PhD Degree

Offered In (Blacksburg)

TOEFL

Paper: (550.0)

Computer: (213.0)

iBT: (80.0)

GRE

General Test: Verbal, Quantitative, Analytical

Doctor of Philosophy (Ph.D.) * MACR 5015/5016: Macromolecular Fundamentals with Laboratory I/II (3 cr) (sample 5015 syllabus, sample 5016 syllabus)* CHEM/CHE 5014 : Technical Oral Communications and Presentation Methods (1 cr.) (sample syllabus)* MACR 5024: Writing Skills for Macromolecular Science and Engineering (1 cr.) (sample syllabus)* Technical Concentration Area (9 cr. from one program module)* MACR Elective Courses (6 cr. from any remaining program modules)* General Electives (9 cr.)* MACR 7994: Research and Dissertation (minimum of 58 cr.)Total Program Hours: 90Advancement to Candidacy Requirements (Ph.D.)* By the end of the 2nd semester in residence, students will submit 1st evaluation after meeting with their major professor.* By the end of the 3rd academic semester in residence, students will submit approved Plan of Study.* By the end of the 4th academic semester in residence, students will write a literature review for their dissertation project, then defend that review orally before their committee.* By the end of the 5th academic semester in residence, students are required to pass a combined written and oral examination focusing on questions pre-submitted by the dissertation committee.* At

least once per year thereafter, the student will orally review his or her research before the dissertation committee (this requirement is due to the highly interdisciplinary nature of the research).

GRADUATE COURSES (MACR)

MACR 5004:

Macromolecular Graduate Seminar

Current topics and literature in macromolecular science and engineering. Principles and best practices for developing research plans and presenting results. Effective scientific communication. Scholarly ethics and research integrity. May be repeated four times with different content for a maximum of 4 credits. Pre: Graduate Standing.

Credit Hour(s): 1

Lecture Hour(s): 1

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

MACR 5015:

Macromolecular Fundamentals Laboratory I and II

The course will cover fundamentals and experimental techniques for the synthesis and characterization of polymeric materials. MACR 5015 includes statistical experimental design, step-growth and chain-growth polymerization, molecular modeling, thermal properties of polymers, molecular weight analysis, morphology, and melt and solution rheology. MACR 5016 includes static and dynamic mechanical analysis, rubber elasticity, spectroscopy, surface analysis, fracture behavior, and basic polymer processing. Must meet pre-requisites or equivalent.

Credit Hour(s): 0 OR 3

Lecture Hour(s): 0 OR 2

Instruction Type(s): Lab, Lecture, Online Lecture

Instruction Type(s): Lab, Lecture, Online Lecture

Prerequisite(s): CHEM 4534 OR CHEM 4634 OR CHE 4104

Corequisite(s):

MACR 5016:

Macromolecular Fundamentals Laboratory I and II

The course will cover fundamentals and experimental techniques for the synthesis and characterization of polymeric materials. MACR 5015 includes statistical experimental design, step-growth and chain-growth polymerization, molecular modeling, thermal properties of polymers, molecular weight analysis, morphology, and melt and solution rheology. MACR 5016 includes static and dynamic mechanical analysis, rubber elasticity, spectroscopy, surface analysis, fracture behavior, and basic

polymer processing. Must meet pre-requisites or equivalent.

Credit Hour(s): 0 OR 3

Lecture Hour(s): 0 OR 2

Instruction Type(s): Lab, Lecture, Online Lecture

Instruction Type(s): Lab, Lecture, Online Lecture

Prerequisite(s): CHEM 4534 OR CHEM 4634 OR CHE 4104

Corequisite(s):

MACR 5024:

Writing Skills in Macromolecular Science and Engineering

This course focuses on methods and critiques for preparing technical abstracts, conference proceedings, technical industrial reports, refereed journal manuscripts and resumes.

Credit Hour(s): 1

Lecture Hour(s): 2

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

MACR 5974:

Independent Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Independent Study, VI

Instruction Type(s): Independent Study, VI

Prerequisite(s):

Corequisite(s):

MACR 5984:

Special Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lab, Lecture, Online Lecture

Instruction Type(s): Lab, Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

MACR 5994:

Research and Thesis

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research

85 Instruction Type(s): Research

Prerequisite(s):

Corequisite(s):

MACR 7994:

Research and Dissertation

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research

Instruction Type(s): Research

Prerequisite(s):

Corequisite(s):

BIOLOGICAL SCIENCES

Robert Cohen, Head

Emeriti Faculty: Ernest Benfield; Joseph Falkinham; Jackson Webster;

Professors: John Barrett; Lisa Belden; Daniela Cimini; Michael Fox; Michael Friedlander; Dana Hawley; Roderick Jensen; Anthony LaMantia; Maria Lazar; Liwu Li; Ignacio Moore; Erik Nilsen; Brent Opell; John Phillips; David Popham; Birgit Scharf; Jill Sible; Ann Stevens; Dorothea Tholl; Jeffrey Walters; Brenda Winkel;

Associate Professors: Bryan Brown; Daniel Capelluto; Cayelan Carey; Carla Finkelstein; Silke Hauf; Joel McGlothlin; Stephen Melville; Florian Schubot; Kendra Sewall; Richard Walker; Zhaomin Yang;

Assistant Professors: Frank Aylward; Jing Chen; Jeremy Draghi; Erin Hotchkiss; Joseph Hoyt; Bryan Hsu; Caroline Jones; Shihoko Kojima; Kate Langwig; Meryl Mims; James Smyth; Josef Uyeda; Susan Whitehead;

Adjunct Professors: Paul Hanson; Christopher Lawrence; Mark Stanback; Michael Strickland; Jenifer Walke;

Affiliated Faculty: Caglar Akcay; Rami Dalloul; Angela Hornsby; Leah Johnson; Samy Lamouille; Stefanie Robel; John Socha; Christopher Thompson;

Harold Bailey Professor: Jeffrey Walters;

Assistant Professor of Practice: Lori Blanc; James Tokuhisa;

Graduate Contact: BiologyGrad@vt.edu

Graduate Site: <http://www.biol.vt.edu/graduates/index.html>

The Department of Biological Sciences offers research and training that lead to the M.S. and Ph.D. degrees. Graduate students, in consultation with Major Advisors, design programs of study that include cutting edge research, courses that support their particular interests, and at least one semester of a teaching experience. Opportunities for research span the biological disciplines from molecular biology to ecosystems ecology and may include computational, experimental, empirical, theoretical, and/or applied approaches. Our faculty members encourage graduate students to reach their full creative and scholarly potential. We take a holistic approach to graduate education by promoting both research skills and the ability to communicate effectively with professional colleagues and

undergraduate students. In addition to their research program, graduate students may elect to earn a graduate certificate in "The Future Professoriate," which includes mentored classroom teaching. In short, our program fosters individually tailored programs that lead to successful careers in research and education. We encourage prospective students to visit the department's webpage to learn about research focus areas and associated interdepartmental programs, and to explore the research programs of potential Major Advisors by perusing faculty web pages. Contacting individual faculty members and their students prior to formal application provides opportunities to explore mutual interests. Deadlines To compete for financial aid, applications for fall admission must be completed by December 15. Applications are accepted after this date but the opportunities for financial aid are diminished. Most graduate teaching assistantships are awarded by April 1. October 31 is the deadline for spring semester applications (domestic students). We do not accept international applications for spring semester.

SPECIAL FACILITIES

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Introduction

The Department of Biological Sciences occupies modern research facilities in several buildings on the Virginia Tech Blacksburg campus, including Derring Hall, Latham Hall, the Integrated Life Sciences Building, and Life Sciences Building I. Biological Sciences faculty also utilize state-of-the-art research space in the Biocomplexity Institute in Blacksburg and the Virginia Tech Carilion Research Institute in Roanoke. Our research laboratories are well-equipped to conduct research in all areas of biology, from protein structure to microbiology to animals and plants to ecosystems. Graduate students carry out experiments to address challenges in topics such as infectious disease, cancer, water, behavior, and global change. The department houses a variety of advanced microscopy, analytical chromatography, computational, and molecular biology equipment. Support facilities for growth of microorganisms, greenhouses, and animal care are located within or near to department research buildings, as are facilities for advanced genomics, proteomics, spectroscopy, and crystallography. Of particular note is the Massey Herbarium, which contains over 115,000 specimens.

DEGREES OFFERED

MS Degree

Offered In (Blacksburg)

TOEFL

Paper: (577.0)

Computer: (233.0)

iBT: (90.0)

Course work requirements: (18 total graded hours) A minimum of 12 hours at the 5000 level 3 additional hours of seminars A maximum of 3 hours at the 4000 level A total of 18 graded hours and 30 total hours

including research and thesis credits are required. Thesis is required. All biological sciences graduate students must teach a minimum of one semester as a requirement for graduation.

PhD Degree

Offered In (Blacksburg)

TOEFL

Paper: (577.0)

Computer: (233.0)

iBT: (90.0)

Course work requirements: (22 total graded hours) A minimum of 18 graded course hours at the 5000 level 4 additional hours of seminars A total of 22 graded hours and 90 total hours, including research and dissertation credits are required. All biological sciences graduate students must teach a minimum of one semester as a requirement for graduation.

GRADUATE COURSES (BIOL)

BIOL 5024:

Population and Community Ecology

Population dynamics, interspecific interactions, succession, and diversity of plants and animals. Quantitative approaches emphasized. Ecology course required.

Credit Hour(s): 0 OR 4

Lecture Hour(s): 0 OR 3

Instruction Type(s): Lab, Lecture, Online Lecture

Instruction Type(s): Lab, Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

BIOL 5034:

Ecosystem Dynamics

Application of the systems perspective to functional characteristics and dynamics of ecosystems: energy flow, biogeochemical cycling, and stability/resilience in the response to environmental change. Computer simulation of ecosystem response to change. Pre: Graduate Standing.

Credit Hour(s): 4

Lecture Hour(s): 3

Instruction Type(s): Lab, Lecture, VB, Online Lecture

Instruction Type(s): Lab, Lecture, VB, Online Lecture

Prerequisite(s): (MATH 2015 (UG), CS 1014 (UG)) OR (MATH 2015, CS 1014)

Corequisite(s):

BIOL 5064 (ALS 5064) (BCHM 5064):

Seminar in Molecular Cell Biology and Biotechnology

Review and discussion of current problems and literature in molecular cell biology and biotechnology by students, VPI&SU faculty and outside speakers. Students give formal presentations of research results or current literature. May be taken on pass-fail basis. Students enrolled in the MCBB Ph.D. option will be required to give one formal presentation on an A-F basis. Graduate status in participating MCBB departments required.

Credit Hour(s): 1

Lecture Hour(s): 1

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

BIOL 5074:

Stream Ecology

Application of ecological principles to running water environments.

Recitation: critical assessment of contemporary literature and research themes associated with stream ecosystems. Graduate standing required.

Credit Hour(s): 0 OR 4

Lecture Hour(s): 0 OR 3

Instruction Type(s): Lab, Lecture, Online Lecture

Instruction Type(s): Lab, Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

BIOL 5094:

Methods in Biogeochemical Analysis

Quantitative methods in the analysis of air, water, soil and sediment samples for biogeochemical properties and processes. Sample collection, preparation, instrument calibration, operation and troubleshooting, quality assurance and reporting of biogeochemical data. Pre: Graduate Standing.

Credit Hour(s): 2

Lecture Hour(s): 1

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

BIOL 5104:

Advanced Developmental Biology

Morphological, physiological and molecular events in embryological and developmental systems, including regulation at the level of transcription, translation, and enzyme or hormone activation. Review of the current literature. Pre-requisite: Graduate standing required.

Credit Hour(s): 4

Lecture Hour(s): 4

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

BIOL 5114:

Advanced Global Change Ecology

Human alterations of climate, landscapes and biogeochemical cycling influence ecological structure and functioning at the global scale. Such changes have the potential to disrupt natural and managed ecosystems with potentially significant biological and economic impacts. This course will examine the influences of these global changes on ecosystem processes and biodiversity, drawing on paleo-and contemporary examples. Current and future potential feedbacks between biological systems and the global environment will also be addressed. Pre:

Graduate standing.

Credit Hour(s): 4

Lecture Hour(s): 4

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

BIOL 5134:

Advanced Evolutionary Genetics

Genetic variation, agents of change in gene frequencies, molecular evolution, mechanisms of speciation, ecological speciation. Comparison of theoretical models with natural and laboratory populations.

Credit Hour(s): 4

Lecture Hour(s): 4

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

BIOL 5154:

Exercises in Grantsmanship

All aspects of obtaining grant funding in the sciences. Grant writing, ethics, development of proposals for national funding agencies, the peer review system, and participation in a mock grant panel meeting. Pre-requisite: Graduate Standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

BIOL 5174:

Graduate Seminar

Offered in the major subdisciplines of biology.

Credit Hour(s): 1

Lecture Hour(s): 1

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

BIOL 5184:

Prokaryot Recombinant Proteins

Concepts of bacterial recombinant protein expression, purification, and handling. Protein bioinformatics resource and the functional characterization of proteins with biochemical and biophysical techniques. Discussion of research articles related to class topics. Prerequisite: Graduate Standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): BCHM 4115

Corequisite(s):

BIOL 5304:

Plant Stress Physiol

Analysis of physiological responses of agricultural and native plants to environmental stresses such as extremes of temperature, availability of water and nutrients, and presence of air pollutants. Emphasis on linking stress caused changes in carbon gain, water loss, nutrient utilization, and energy balance with changes in growth. Laboratory to introduce equipment and research approaches used in greenhouse and field studies.

Credit Hour(s): 4

Lecture Hour(s): 3

Instruction Type(s): Lab, Lecture, VB, Online Lecture

Instruction Type(s): Lab, Lecture, VB, Online Lecture

Prerequisite(s):

Corequisite(s):

BIOL 5334:

Advanced Chemical Ecology

Chemical interactions between organisms with emphasis on the plant
88 biosphere. Fundamental concepts, theories, and general methodology of

chemical ecology; mechanisms of chemically-mediated interactions between plants and other organisms; effects of global change on chemical interactions; and engineering of natural chemical defenses in sustainable agriculture. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

BIOL 5404:

Neuroethology

Overview of Neuroethology, the study of the neural basis of animal behavior. Topics include: organization of the nervous system, control and coordination of movement, sensory transduction, visual and auditory prey detection and recognition, visual communication, matched filters/predictive coding of sensory information, learning templates, computational maps, sensory integration, behavioral plasticity, spatial cognition, neural plasticity, and lateralization of neural function.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

BIOL 5424 (GBCB 5424) (CS 5424):

Computational Cell Biology

Use of mathematical models (nonlinear ordinary differential equations and stochastic processes) and simulation algorithms to explore the complex feedback circuits that control the behavior of living cells. Concepts and techniques from dynamical systems theory, bifurcation analysis, numerical methods, SBML (systems biology markup language) and Matlab programming. Applications in gene regulatory networks, cell cycle control, circadian rhythms, cell signaling.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): MATH 5515

Corequisite(s):

BIOL 5434:

Behavioral Endocrinology

Overview of the hormonal basis of animal behavior. Topics: include: sex differences in behavior, male and female reproductive behavior, parental

behavior, aggressive and other social behaviors, stress, affective disorders, learning and memory, homeostasis, and biological rhythms.

Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

BIOL 5504:

Quantitative Methods in Ecology and Evolution

Approaches for data curation, plotting, manipulation, and analysis in ecology and evolution. Statistical philosophies as applied to ecological and evolutionary datasets. Hypothesis testing, model comparison, linear, generalized linear, and mixed models. Quantitative literacy in ecology and evolution. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

BIOL 5514:

Quantitative Analysis Of High-Dimensional Ecological Data

Analyses of high-dimensional ecological data such as those produced from environmental surveys and studies of ecological communities. Curation and visualization of complex data; quantifying diversity; concepts of ecological similarity; testing for differences in high-dimensional space. Application of techniques to case histories and/or students own data. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

BIOL 5564:

Adv Infectious Disease Ecology

Advanced overview of the principles of infectious disease dynamics from ecological and evolutionary perspectives. Examines a variety of wildlife hosts and disease-causing agents. Selective coverage of specific host and pathogen models to illustrate underlying principles of wildlife disease emergence, maintenance, and spread, as well as connections between wildlife and human health. Pre-requisite: Graduate Standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

BIOL 5624:

Advanced Microbial Genetics

Molecular genetics of bacteria and their associated plasmids and phages. Review of research from the current literature for methodology and standards of data analysis.

Credit Hour(s): 4

Lecture Hour(s): 4

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

BIOL 5634:

Microbial Physiology

The study of the structure, function and metabolic activities of prokaryotic microorganisms. Topics covered include cell composition and growth, metabolic unity and diversity, patterns of regulation, transport mechanisms, environmental sensing and response and cellular differentiation processes. Students will give presentations and critically analyze current literature in the field.

Credit Hour(s): 4

Lecture Hour(s): 4

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

BIOL 5664G:

Advanced Virology

Classification, structure, replication, and pathogenesis of viruses of animals, plants and bacteria. Epidemiology, prevention, and treatment.

Prerequisite: Graduate Standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

BIOL 5674:

Advanced Pathogenic Bacteriology

Characteristics of bacteria that cause human disease, nature of infectious processes and the host immune system, virulence factors, epidemiology, resistance, immunization. Current research in bacterial pathogenesis. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

BIOL 5734:

Advanced Inflammation Biology

Cellular and molecular pathways controlling human responses to inflammatory challenges. Regulation of immune cells during inflammation. Interaction of host cells and tissues with environmental risk factors that cause inflammation. Pathogenesis of inflammatory diseases including cardiovascular diseases, diabetes, multi-organ failure, neurological diseases and sepsis. Therapeutic intervention of inflammatory diseases. Discussion of current literature. Integrative approached to study of inflammation will be critically evaluated and synthesized. Prerequisite: Graduate Standing required.

Credit Hour(s): 4

Lecture Hour(s): 4

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

BIOL 5824G:

Advanced Bioinformatic Methods

Application of bioinformatics methods in biological research. Methods to access bioinformatics data. Theory and methods for analysis of DNA sequences, and analysis of complex data sets including whole genome sequences and gene expression data. Use of standard bioinformatics software and databases. Pre: Graduate Standing.

Credit Hour(s): 3

Lecture Hour(s): 2

Instruction Type(s): Lab, Lecture, VB, Online Lecture

Instruction Type(s): Lab, Lecture, VB, Online Lecture

Prerequisite(s):

Corequisite(s):

BIOL 5834G:

Adv Prac Analysis Prot Str Fnc

of protein structure and function, macromolecular interactions and conformational changes. Strategies, experimental design, practical considerations, troubleshooting, data analysis. Pre: Graduate Standing.

Credit Hour(s): 3

Lecture Hour(s): 2

Instruction Type(s): Lab, Lecture, VB, Online Lecture

Instruction Type(s): Lab, Lecture, VB, Online Lecture

Prerequisite(s):

Corequisite(s):

BIOL 5844:

Advanced Proteomics and Biological Mass Spectrometry

Introduction to mass spectrometry (MS) instrumentation and advanced proteomic methods for systems biology applications. Peptide mass fingerprinting, tandem MS, quantitation, phospho/glyco proteomics, and bioinformatics tools for evaluation and interpretation of mass spectrometry data. Includes three 4-hour lab sessions. Prerequisite:

Graduate Standing required.

Credit Hour(s): 4

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

BIOL 5854G:

Advanced Cytogenetics

Structure and function of eukaryotic chromosomes, with emphasis on (i) use of model systems to study specific chromosomes substructures or functions; (ii) techniques used to identify and classify both normal and aberrant chromosomes; and (iii) diseases caused by defective chromosome structure and/or function. Prerequisite: Graduate Standing required

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

BIOL 5884:

Molecular Biology of the Cell

Current concepts of the molecular organization of animal and plant cells. Topics include membrane structure and function, organelle biosynthesis and function, intracellular signaling, the cytoskeleton, the cell cycle, tissue formation and modern experimental methodologies.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): (BIOL 3774 (UG) OR BCHM 4116 (UG)) OR (BIOL 3774 OR BCHM 4116)

Corequisite(s):

BIOL 5974:

Independent Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Independent Study, VI

Instruction Type(s): Independent Study, VI

Prerequisite(s):

Corequisite(s):

BIOL 5984:

Special Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

BIOL 5994:

Research and Thesis

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research, Online Research

Instruction Type(s): Research, Online Research

Prerequisite(s):

Corequisite(s):

BIOL 6004:

Topics in Ecology and Systematics

Reading and discussion in a specific area of ecology and systematics.

Topic will vary, and course may be taken for credit more than once.

Background in ecology or systematics required.

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Corequisite(s):

BIOL 6014:

Topics in Evolutionary Biology

Readings and discussion in a specific area of evolutionary theory, ecological genetics, or molecular evolution. Topics will vary, and course may be taken for credit more than once. Background in genetics and population biology required.

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

BIOL 6064:

Topics in Freshwater Ecology

Readings and discussion in a specific area of freshwater ecology, including species interactions, and community level functions. Topics will vary, and course may be taken for credit more than once.

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): BIOL 4004

Corequisite(s):

BIOL 6084:

Topics in Cell and Developmental Biology

Readings and discussion of a focused area of cellular and developmental biology, including cell signaling, cell cycle, differentiation and morphogenesis, cytoskeletal regulation and cell death. Topics vary each semester and course may be repeated with different content up to a maximum of 12 credits. Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): BIOL 5884 OR BIOL 4104 (UG) OR BIOL 4104

Corequisite(s):

BIOL 6404:

Topics In Vertebrate Biology

Readings and discussion in a specific area of vertebrate biology. Topic will vary, and course may be taken for credit more than once.

Background in vertebrate biology required.

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

BIOL 6704:

Topics in Immunology

Readings and discussion in a specific area of immunology. Topic will vary and course may be taken for credit more than once.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): BIOL 4704 (UG) OR BIOL 4704

Corequisite(s):

BIOL 6984:

Special Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

BIOL 7994:

Research and Dissertation

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research, Online Research

Instruction Type(s): Research, Online Research

Prerequisite(s):

Corequisite(s):

CHEMISTRY

Alan Esker, Head

Emeriti Faculty: Harry Gibson; Herve Marand; Harold McNair; Judy Riffle; Sam Turner;

Professors: Paul Carlier; Daniel Crawford; Harry Dorn; Alan Esker; Felicia Etkorn; Richard Gandour; David Kingston; Timothy Long; Louis Madsen; Joseph Merola; Robert Moore; John Morris; Webster Santos; James Tanko; Eduard

Valeyev;

Associate Professors: Paul Deck; Gary Long; John Matson; Amanda Morris;

Brian Tissue; Diego Troya; Gordon Yee;

Assistant Professors: Diana Iovan; Jatinder Josan; Feng Lin; Guoliang Liu;

Andrew Lowell; Nicholas Mayhall; Emily Mevers; Michael Schulz; Valerie Welborn;

University Distinguished Professor: Daniel Crawford; David Kingston;

Dr. A. C. Lilly, Jr., Faculty Fellow of Nanoscience: John Morris;

Cliff and Agnes Lilly Faculty Fellow: Webster Santos;

Graduate Contact: jolih@vt.edu

Graduate Program Director: jrmorris@vt.edu

Graduate Admissions Director: jbmatson@vt.edu

Graduate Site: <https://chem.vt.edu/academics/graduate.html>

Student Handbook:

https://chem.vt.edu/content/dam/chem_vt_edu/graduate/Graduate%20Orange%20Book%202019.pdf

Admissions: <https://chem.vt.edu/academics/graduate/prospective-students.html>

The Chemistry Department is consistently top-ranked among its peers in terms of degree production (BA, BS, MS, & PhD) and research expenditures. Our 30 faculty members and 140 graduate students generate over 100 peer-reviewed publications per year and have earned numerous prestigious awards for research, teaching, and outreach. In addition to the major areas of chemistry (analytical, inorganic, organic, and physical), our polymer chemistry program has been ranked among the top 5, and we have highly developed programs in several interdisciplinary areas including drug discovery, computational and theoretical chemistry, surface science, renewable energy, and chemical biology.

SPECIAL FACILITIES

The Chemistry Department is housed in three adjoining buildings. Davidson Hall is the original chemistry building, which has recently undergone renovation. Davidson Hall features both classrooms and research laboratories. Hahn Hall South Wing is exclusively devoted to research, and the building features a lovely atrium gathering space. Hahn Hall North Wing houses our teaching laboratories and several conference rooms. Additional research space is occupied by the Chemistry Department in the Institute for Critical Technologies and Applied Science (ICTAS). Other equipment available to Chemistry researchers includes an 1100-node supercomputer (System X), several smaller computational clusters and a broad range of microscopy equipment (AFM, STM, SEM, and optical) and nanoscale fabrication hardware.

Analytical Services Center

Our Analytical Services Center houses six NMR spectrometers, including one at 600 MHz, one at 500 MHz, four at 400 MHz (including a wide-bore instrument for imaging experiments) and a 300 MHz instrument dedicated to solid samples. All modern techniques (multidimensional, multinuclear, variable temperature) are available. Analytical Services also includes LCMS, GCMS, including accurate-mass capability on our Agilent ESI-TOF instrument. Analytical labs are

fully staffed with professional spectrometrists.

College of Science -- Crystallography Laboratory

Our X-ray diffractometer is housed in the College of Science Crystallography Laboratory (VTX), which features a range of diffractometers and a capabilities such as ultra-low temperature (to 15 K), high pressure (to 10 GPa), and the ability to analyze small crystals and proteins.

Polymer Characterization Laboratory

The polymer characterization laboratory features GPC, TGA, and DSC, as well as mechanical and rheological testing instruments.

Surface Analysis Laboratory

The Surface Analysis Laboratory features XPS, Auger, and AFM instruments.

DEGREES OFFERED

MS Degree

Offered In (Blacksburg)

TOEFL

Paper: (600.0)

Computer: (250.0)

iBT: (100.0)

GRE

General Test: Verbal, Quantitative, Analytical

IELTS

General Test: (8.0)

This section offers brief synopses of the programmatic requirements for the M.S. and Ph.D. degrees in Chemistry at Virginia Tech. Applicants and current students are directed to our policies and procedures manual for the complete, detailed description of these requirements. The link to the manual can be found on the Current Students section of our website: <https://chem.vt.edu/academics/graduate/current-students.html> The M.S. degree may be earned in one of two ways. The student may prepare and defend a Master's Thesis; alternatively there is a non-thesis M.S. option that is based exclusively on course work. The Thesis M.S. degree requires 20 credit hours of graduate course work, the presentation of one seminar, and the preparation and oral defense of the M.S. thesis. The non-thesis M.S. degree requires 24 credit hours of regular graduate course work plus 6 credit hours of report-based courses.

PhD Degree

Offered In (Blacksburg)

TOEFL

Paper: (600.0)

Computer: (250.0)

iBT: (100.0)

GRE

General Test: Verbal, Quantitative, Analytical

IELTS

General Test: (8.0)

This section offers brief synopses of the programmatic requirements for the M.S. and Ph.D. degrees in Chemistry at Virginia Tech. Applicants and current students are directed to our policies and procedures manual for the complete, detailed description of these requirements. The link to the manual can be found on the Current Students section of our website: <https://chem.vt.edu/academics/graduate/current-students.html> Each doctoral student must complete a minimum of four graduate-level courses. The selection of courses depends on the student's research interests and are established in consultation with the student's Advisory Committee. Some additional courses may be required to ensure that the student has a broad Foundation of knowledge; these courses are determined by the student's performance on entrance examinations in Inorganic Chemistry, Organic Chemistry, Physical Chemistry, and Instrumental Analysis administered during Orientation Week. Each doctoral student also must complete two report courses; in the first enrollment (3rd semester of residence) a Literature Review is prepared, and in the second enrollment (6th semester of residence) an Original Research Proposal is prepared. Each doctoral student also must present two seminars and satisfy annual reporting and evaluation requirements as specified in the document linked above.

GRADUATE COURSES (CHEM)

CHEM 5004:

Orientation to Graduate Research

A survey of topics needed to meet high standards of safety, scholarship, and productivity in research-based chemistry graduate programs.

Graduate standing required.

Credit Hour(s): 1

Lecture Hour(s): 1

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CHEM 5014 (CHE 5014) (MSE 5014):

Communication Skills and Methods of Presentation

Methods and style to make effective technical and nontechnic presentations including blackboard presentations, overhead presentations, slide presentations, and research posters. Video presentations with critiques.

Credit Hour(s): 1

Lecture Hour(s): 1

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CHEM 5094 (FST 5094) (BMVS 5094):

Grant Writing and Ethics

A framework for writing clear, concise grant proposals in a team-oriented, multidisciplinary approach from concept development through submission to a funding agency. Potential ethical dilemmas that may arise in academic, industrial, or federal research settings will be discussed. Pre: Undergraduate courses in one of the following: organic chemistry (CHEM 2565/2566), cell & molecular biology (BIOL 2104), Concepts of Biochemistry (BCHM 2024), or equivalent. Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CHEM 5114:

Advanced Electrochemistry

Discussion of theory and application of chemical equilibrium, reaction rate methods, and electroanalytical methods in analytical chemistry. One year of physical chemistry required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CHEM 5124:

Analytical Spectroscopy

Principles, instrumentation, and applications of atomic and molecular spectroscopy. Theoretical descriptions of electronic and ro-vibrational energy levels, transitions, and energy dynamics. Modern spectroscopic instrumentation and applications in quantitative analyses. Prerequisite or equivalent.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): CHEM 3616 (UG) OR CHEM 36616

Corequisite(s):

CHEM 5134:

Introduction to Single-Crystal X-ray Diffraction

Overview of single-crystal X-ray crystallographic theory and methods for graduate students who make (or plan to make) occasional use of crystallographic data or measurements in their research. Capabilities

(VTX). Preparation and submission of crystalline samples. Typical processes of crystal screening, data collection, structure solution, and data reporting. Current standards for publication of crystallographic data. Crystallography software and structural databases. Ethical standards for reporting crystallographic data. Radiation safety in crystallography. Pre: Graduate standing. Pass/Fail only.

Credit Hour(s): 1

Lecture Hour(s): 1

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CHEM 5144:

Instrument Design

Design, construction, and operating principles of analytical instrumentation. Topics will include major instrument components (vacuum, optical, charged-particle), instrument construction (spectrometers, chromatographs), electronic data acquisition, and computer data analysis.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CHEM 5154:

Methods in Molecular Biophysics

Modern methods of biophysical measurement, their strengths and limitations, and their application to current research problems. Mass spectrometry, differential scanning calorimetry, isothermal titration calorimetry, surface plasmon resonance, atomic force microscopy, electrophoresis, and fluorescence spectroscopy of biomacromolecules.

Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CHEM 5174 (ESM 5174):

Polymer Viscoelasticity

Constitutive models of linear viscoelastic materials, experimental aspects, polymer response to mechanical and electrical inputs, solid state NMR and microwave interactions with polymers, free volume

theories, temperature and environmental effects on polymers, physical aging of glasses. Consent required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CHEM 5404:

Advanced Inorganic Chemistry

An advanced coverage of topics in inorganic chemistry: principles of bonding in compounds of the metals and non-metals, applications of group theory to bonding, ligand field theory, inorganic and organometallic reaction mechanisms. Required core course for chemistry graduate students. One semester of undergraduate inorganic chemistry, one year undergraduate physical chemistry required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CHEM 5414:

Methods & Appl of Inorg Chem

Physical methods of measurement in modern inorganic chemistry research. Theoretical and practical aspects of spectroscopy, electrochemistry, photo-chemistry, and surface-analytical techniques as applied to inorganic compounds. Intersections of inorganic chemistry with nanotechnology, materials science, heterogeneous catalysis, and biochemistry, as reflected in the primary research literature. Pre: Graduate Standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CHEM 5424G:

Adv Polysaccharide Chemistry

Structure, properties, and application of natural polysaccharides. Natural sources and methods of isolation. Synthetic chemistry and important polysaccharide derivatives Relation of structure and properties of performance in critical applications including pharmaceuticals, coatings, plastics, rheology control, and films. Conversion by chemical and

biochemical methods of polysaccharide biomass to fuels and materials.

Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CHEM 5505:

Advanced Organic Chemistry

Structure, stereochemistry, and bonding in organic compounds and their effects on organic reactivity. Ionic reactions, free radical reactions, and concerted reactions will be discussed. One year of undergraduate organic chemistry required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CHEM 5506:

Advanced Organic Chemistry

Structure, stereochemistry, and bonding in organic compounds and their effects on organic reactivity. Ionic reactions, free radical reactions, and concerted reactions will be discussed.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): CHEM 5505 (UG) OR CHEM 5505

Corequisite(s):

CHEM 5514G:

Advanced Green Chemistry

Sustainability, waste prevention, conservation of energy resources, avoidance of toxins, pollutants, and hazards in chemical processes and products. Life-cycle analysis applied to case studies involving process development and product stewardship. Applications in chemical industry, process and product design, and public policy. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CHEM 5524:

Molecular Structure Determination

Structure determination of organic compounds by spectroscopic methods, with an emphasis on mass spectrometry and nuclear magnetic resonance. Course will emphasize problem-solving skills. Includes hands-on instruction in nuclear magnetic resonance spectroscopy and other analytical spectroscopic methods. Partially duplicates 4524; students cannot receive credit for both 4524 and 5524.

Credit Hour(s): 0 OR 4

Lecture Hour(s): 0 OR 3

Instruction Type(s): Lab, Lecture, Online Lecture

Instruction Type(s): Lab, Lecture, Online Lecture

Prerequisite(s): CHEM 2536 (UG), (CHEM 3616 (UG) OR CHEM 4616 (UG)) OR CHEM 2536, (CHEM 3616 OR CHEM 4616)

Corequisite(s):

CHEM 5525 (GEOS 5535):

X-ray Crystallography

5525: Provides a thorough grounding in the principles of the crystalline state including lattices and symmetry, leading to the formal description of structures and surfaces and interpretation of published crystallographic data. 5526: Covers methods of single-crystal and powder X-ray diffraction for the determination of the atomic arrangement of atoms within crystalline materials.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): GEOS 3504 OR CHEM 3615

Corequisite(s):

CHEM 5526:

X-RAY CRYSTALLOGRAPHY

5525: Provides a thorough grounding in the principles of the crystalline state including lattices and symmetry, leading to the formal description of structures and surfaces and interpretation of published crystallographic data. 5526: Covers methods of single-crystal and powder X-ray diffraction for the determination of the atomic arrangement of atoms within crystalline materials.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): GEOS 5535 OR CHEM 5525

Corequisite(s):

CHEM 5535:**Synthetic Organic Chemistry**

Modern synthetic methods and their applications to the preparation of various classes of organic compounds.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): CHEM 5505 (UG) OR CHEM 5505

Corequisite(s):

CHEM 5614:**Nuclear Magnetic Resonance Methods in Chemistry and Polymer Science**

Theory and methods of nuclear magnetic resonance (NMR). Description and operation of NMR apparatus and experimental techniques.

Optimization of NMR experiments with respect to spin relaxation, sensitivity, and resolution. Spin couplings and associated spectral features. Applications in the characterization and analysis of molecules, solids, and polymers. Theory and basic practices of solution, solid-state, and multidimensional NMR methods. Spatial imaging (MRI) and molecular diffusion (diffusometry) methods. Pre: Graduate standing

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CHEM 5644:**Colloid and Surface Chemistry**

Characterization of interfaces including liquid/gas and liquid/liquid (spread monolayers) interfaces, nature of solid surfaces, gas/solid (thermodynamics), and liquid/solid (wetting, colloidal stability) interfaces.

Pre: One year of physical chemistry or consent.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CHEM 5664:**Chemical Kinetics**

Phenomenological kinetics with emphasis on measurement techniques and the interpretation of kinetic data. Significance of rate laws, activation parameters for mechanisms, catalysis and fast reactions in gas and

condensed phase are discussed.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): CHEM 5614 (UG) OR CHEM 5614

Corequisite(s):

CHEM 5704:**Synthesis and Reactions of Macromolecules**

Advanced treatment of the kinetics, mechanisms, synthesis and reactions of macromolecules via step and chain processes. Pre: Second year grad standing in chemistry, chemical engineering, or consent.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CHEM 5805:**Applied Chemistry: Review & Proposal**

5805: Review of an active industrial product or process in the field of food, energy and water chemistry; drug discovery chemistry; or polymer chemistry. Assessment of trends in the academic and patent literature relevant to commercial products and processes. Scholarly management of personalized citation databases. A-F only. Pre: Graduate Standing.

5806: Written proposal and oral presentation defense of a possible development study in the field of food, energy and water chemistry; drug discovery chemistry; or polymer chemistry. Literature frameworks and precedent for development studies. Cost-benefit analysis in chemical process and product development. Oral presentation and defense of a process development proposal. A-F only.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CHEM 5806:**Applied Chemistry: Review & Proposal**

5805: Review of an active industrial product or process in the field of food, energy and water chemistry; drug discovery chemistry; or polymer chemistry. Assessment of trends in the academic and patent literature relevant to commercial products and processes. Scholarly management of personalized citation databases. A-F only. Pre: Graduate Standing.

5806: Written proposal and oral presentation defense of a possible development study in the field of food, energy and water chemistry; drug discovery chemistry; or polymer chemistry. Literature frameworks and precedent for development studies. Cost-benefit analysis in chemical process and product development. Oral presentation and defense of a process development proposal. A-F only.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): CHEM 5805

Corequisite(s):

CHEM 5834:

Food, Energy, and Water Chemistry

Roles of chemistry in food production, energy utilization, and water management. Integration of sustainable food-energy-water (FEW) chemistry in progress toward environmental stewardship and resource efficiency. Principles of equilibria and speciation, reaction kinetics, wet-analytical and instrumental methods, synthesis, and physical characterization of materials emphasizing applications of FEW chemistry including water-purification materials and green agrochemical production. Analysis of current academic and patent literature describing developing chemical technologies relevant to the food, energy, and water nexus. Pre: Graduate standing

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CHEM 5854:

Entrepreneurship in Medicinal Chemistry

History of entrepreneurship in medicinal chemistry. Survey of industrial medicinal chemistry sectors from small ventures to major pharmaceutical companies. Business plan development and venture capitalism. Case studies of medicinal chemistry ventures. Business and legal aspects of translating scientific discovery into intellectual property (IP), industrial processes, and competitive advantage. Academic technology-transfer procedures. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CHEM 5894:

Final Examination

For non-thesis candidates who are required to register for their final examination and have completed their program of study. Not to be included in minimum hours required for degree.

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CHEM 5904:

Project and Report

A detailed written report on a current topic in chemistry or interdisciplinary areas involving chemistry. Non-thesis M.S. students in chemistry are required to complete 4 credit hours of CHEM 5904.

Graduate standing in chemistry required.

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research, Online Research

Instruction Type(s): Research, Online Research

Prerequisite(s):

Corequisite(s):

CHEM 5914:

Literature Review and Research Plan

Preparation of a written review of a topical research area within chemistry or a closely allied interdisciplinary field. Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CHEM 5944:

Graduate Seminar

Recent advances in various fields of chemistry are covered by means of reports carefully prepared and presented by individual students, under direction of various members of chemistry faculty. Work of each student is judged not only by report he gives but also by an intelligent discussion of reports presented by other students.

Credit Hour(s): 1

98 Lecture Hour(s): 1

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CHEM 5974:

Independent Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Independent Study, VI

Instruction Type(s): Independent Study, VI

Prerequisite(s):

Corequisite(s):

CHEM 5984:

Special Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CHEM 5994:

Research and Thesis

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research, Online Research

Instruction Type(s): Research, Online Research

Prerequisite(s):

Corequisite(s):

CHEM 6434:

Organometallic Chemistry

Chemistry and applications of organometallic and related compounds.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CHEM 6464:

Current Topics in Inorganic Chemistry

Special topics in frontier areas of inorganic chemistry. Offered when appropriate.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CHEM 6504:

Chemistry of Natural Products

The structures, biosyntheses, reactions, and biomimetic syntheses of natural products, with examples from each of the major classes of polyketides, shikimates, terpenoids, alkaloids, antibiotics, and marine natural products.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): CHEM 5506 (UG) OR CHEM 5506

Corequisite(s):

CHEM 6564:

Current Topics in Organic Chemistry

Special topics in frontier areas of organic chemistry. Offered when appropriate.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): CHEM 5506 (UG) OR CHEM 5506

Corequisite(s):

CHEM 6624:

Chemical Thermodynamics

Rigorous application of the laws of thermodynamics to real fluids, solutions, chemical equilibria, and non-equilibrium processes.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): CHEM 5614 (UG) OR CHEM 5614

Corequisite(s):

CHEM 6634:

Study of basic quantum mechanics followed by some of its applications to chemistry and spectroscopy. Topics include: the variational method; perturbation theory; Hartree-Fock theory; the electronic structures of atoms and molecules; atomic spectra; and molecular rotational, vibrational, and electronic spectra.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): CHEM 5614 (UG) OR CHEM 5614

Corequisite(s):

CHEM 6664:

Current Topics in Physical Chemistry

Special topics in frontier areas of physical chemistry. Offered when appropriate.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): CHEM 5614 (UG) OR CHEM 5614

Corequisite(s):

CHEM 6904:

Generating Research Ideas

Process of generating and evaluating novel research ideas in chemistry.

Pre: Graduate Standing.

Credit Hour(s): 1

Lecture Hour(s): 1

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CHEM 6914:

Original Research Proposal

Preparation of a written original research proposal in chemistry or a closely related interdisciplinary field. Must have passed the Preliminary Oral Exam.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): CHEM 5914

Corequisite(s):

CHEM 6984:

Special Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CHEM 7994:

Research and Dissertation

NONE

Credit Hour(s): 1 TO 20

Lecture Hour(s):

Instruction Type(s): Research, Online Research

Instruction Type(s): Research, Online Research

Prerequisite(s):

Corequisite(s):

ECONOMICS

Sudipta Sarangi, Head

Emeriti Faculty: Amoz Kats;

Professors: Richard Ashley; Sheryl Ball; Niloy Bose; Hans Haller; Djavad Salehi-Isfahani; Sudipta Sarangi; Aris Spanos; Thorwald Tideman;

Associate Professors: Eric Bahel; Richard Cothren; Adam Dominiak; Suqin Ge; Xu Lin; Kwok Tsang;

Assistant Professors: Ali Habibnia; Siddharth Hari; Shaowen Luo; Melinda Miller; Benjamin Rosa; Alexander Smith; Gerelt Tserenjigmid;

Wilson Schmidt Professor: Aris Spanos;

Advanced Instructors: Gebremeskel Gebremariam;

Collegiate Assistant Professors: Matthew Kovach; Steven Trost;

General Contact: astanfor@vt.edu

Graduate Program Director: nbose@vt.edu

Graduate Contact: wibebout@vt.edu

Graduate Program: <https://www.econ.vt.edu>

The Virginia Tech Economics program was established September 1, 1961, and since then, has awarded more than 200 doctoral degrees in economics. From 2000 onwards, the program has taken a new direction - while students still earn a doctorate in Economics, the program is jointly administered by the Department of Economics and the Department of Agricultural and Applied Economics, giving students access to a greater number of courses. 1. Curriculum - The Ph.D. program is designed to be completed in 4-5 years, with the first 2 years focused on coursework and the remaining years on research and completion of the dissertation.

Following a set of compulsory core courses in microeconomics, macroeconomics, and econometrics in the first two years, the students take more advanced and specialized field courses in areas like applied microeconomics (health, labor, and development economics), microeconomic theory, experimental and behavioral economics, econometrics, and macroeconomics. They must pass a Qualifying Exam at the end of the first year and before the end of their third year, students must complete a Third Year Research Paper. Each student is expected to successfully defend a doctoral dissertation by the end of the fourth or fifth year in the program.

2. Career - The doctoral program in economics prepares students for research and teaching careers, as well as careers in the public and private sectors that require knowledge and understanding of the most advanced economic theory and methods. Our recent graduates have found jobs as successful professionals worldwide in a variety of academic institutions, in the finance and investment industry, other large business corporations, and both the non-government and the government sectors.

3. Faculty Research - The faculty members conduct research in diverse fields including i) Microeconomic Theory & Game Theory, ii) Applied Microeconomics (Labor, Development, Industrial Organizations, and History), iii) Experimental & Behavioral Economics, iv) Econometrics, v) Resource & Environmental Economics, and vi) Macroeconomics and Finance.

4. What Sets Us Apart - In addition to conducting research in core subject areas, the economics faculty engages in research in the emerging and cutting-edge interdisciplinary fields such as behavioral economics, big-data science, decision theory, and neuroeconomics. As a medium-sized department, our doctoral students receive personalized attention and start collaborating with faculty members in their career. Participation in conferences and workshops is encouraged and students also actively participate in self-created research groups.

SPECIAL FACILITIES

The Department

Students on assistantship are allocated office space in the department in Pamplin Hall. All students have access to computers in their office with internet access. The department has an experimental economics lab in 2088 Derring Hall.

DEGREES OFFERED

PhD Degree

Offered In (Blacksburg)

TOEFL

Paper: (600.0)

Computer: (250.0)

iBT: (90.0)

GRE

General Test: Quantitative (155.0)

Students seeking the Ph.D. must complete 90 total credit hours of work, consisting of 24 credit hours of core requirements, 21 credit hours of field courses, 30 credit hours of research & dissertation, and an additional 15 credit hours of research & dissertation or other Graduate level courses with the permission of the Graduate Director. The

Economics Department does not offer a free standing terminal master's program. The M.A. degree in Economics is intended to serve advanced VT undergraduate students who participate in the 5th year B.S./M.A. program and those Ph.D. students who begin their studies but are unable to complete the program. The Economics Department does not offer Spring admission. Nor does it offer summer courses for graduate students. The PhD in Economics is a STEM discipline.

GRADUATE COURSES (ECON)

ECON 5005:

Prices, Markets, and Resource Allocation

This sequence, which is part of the core curriculum in the Economics Ph.D. program, covers fundamental concepts at the foundation of modern microeconomic theory. The sequence relies heavily on calculus and other mathematical tools. 5005: noncooperative game theory, competitive and non-competitive markets, theory of the firm. 5006: consumer theory, general equilibrium and welfare economics, uncertainty and asymmetric information.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ECON 5006:

Prices, Markets, and Resource Allocation

This sequence, which is part of the core curriculum in the Economics Ph.D. program, covers fundamental concepts at the foundation of modern microeconomic theory. The sequence relies heavily on calculus and other mathematical tools. 5005: noncooperative game theory, competitive and non-competitive markets, theory of the firm. 5006: consumer theory, general equilibrium and welfare economics, uncertainty and asymmetric information.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECON 5005 (UG) OR ECON 5005

Corequisite(s):

ECON 5015:

Theory of Money, Income, Employment, and the Price Level

Part of core curriculum in the Econ Phd program providing an intensive treatment of modern macroeconomic and monetary theory. The course uses mathematical tools and analytic concepts. National income

accounts; effective demand; neoclassical and Keynesian theories of capital and interest; supply and demand in money securities markets; introduction to macroeconomic dynamics; rational expectations.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s): null null

ECON 5016:

Theory of Money, Income, Employment, and the Price Level

Part of core curriculum in the Econ PhD program providing an intensive treatment of modern macroeconomic and monetary theory. The course uses mathematical tools and analytic concepts. National income accounts; effective demand; neoclassical and Keynesian theories of capital and interest; supply and demand in money securities markets; introduction to macroeconomic dynamics; rational expectations.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECON 5015 (UG) OR ECON 5015

Corequisite(s):

ECON 5124:

Mathematical Methods in Economics

Extensive treatment of new techniques for economic modeling. Review of linear algebra and calculus; static optimization, with Lagrangian and Kuhn-Tucker methods; differential and difference equations; dynamic optimization, with calculus of variations, optimal control and dynamic programming.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ECON 5125 (AAEC 5125):

Empirical Research Methods in Economics

Extensive treatment of new techniques for economic modeling. 5125: Probability and statistical inference, linear regression and related dynamic models, specification, estimation, misspecification, respecification, identification. 5126: Simultaneous equations, dynamic systems, time series, limited dependent variable models.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ECON 5126 (AAEC 5126):

Empirical Research Methods in Economics

Extensive treatment of new techniques for economic modeling. 5125: Probability and statistical inference, linear regression and related dynamic models, specification, estimation, misspecification, respecification, identification. 5126: Simultaneous equations, dynamic systems, time series, limited dependent variable models.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECON 5125 (UG) OR ECON 5125

Corequisite(s):

ECON 5144:

Antitrust and Regulation

Markets and market structure. Methods for analyzing regulatory data. Antitrust law with a focus on U.S. institutions. Vertical and horizontal mergers. Anticompetitive behavior with a focus on collusion and monopolization. Regulation of price, entry, and the environment. Cost-benefit analysis, valuing nonmonetary benefits, and contingent valuation studies.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): STAT 5054, STAT 5214G

Corequisite(s):

ECON 5154:

Empirical Industrial Organization

Basic models and empirical tools in the field of Industrial Organization. Interactions of firms and consumers in markets. Estimation of demand systems. Models of oligopoly and anticompetitive practices. Contractual relationships between businesses. Empirical specification and estimation of static and dynamic models for understanding firm entry and market structure. Models of incentives under asymmetric information and their applications to electronic businesses, financial markets, and health insurance exchanges. Pre: Graduate standing.

Credit Hour(s): 3

102 Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ECON 5894:

Final Examination

NONE

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ECON 5945:

Econometric Theory and Practice

An intensive coverage of the most important techniques of econometric estimation and hypothesis testing, addressing the use of both cross-section and time series data. A core sequence in the MA program in both locations. Prerequisite to the research-thesis seminar in Northern Virginia.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECON 2115 (UG) OR ECON 2116 (UG) OR ECON 2005 (UG) OR ECON 2006 (UG) OR ECON 2125 (UG) OR ECON 2126 (UG) OR ECON 2025H (UG) OR ECON 2026H (UG) OR ECON 2115 OR ECON 2116 OR ECON 2005 OR ECON 2006 OR ECON 2125 OR ECON 2126 OR ECON 2025H OR ECON 2026H

Corequisite(s):

ECON 5946 (AAEC 5946):

Econometric Theory and Practice

An intensive coverage of the most important techniques of econometric estimation and hypothesis testing, addressing the use of both cross-section and time series data. A core sequence in the MA program in both locations. Prerequisite to the research-thesis seminar in Northern Virginia.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): AAEC 5126 OR ECON 5126

Corequisite(s):

ECON 5964:

Experimental Economics

Laboratory techniques are valuable for answering research questions which defy traditional empirical analysis due to lack of field data. Examples include proposed regulations, new market designs and tests of theory. The goal of this course is two-fold: to develop skills in experimental methods appropriate for economics and related fields and to familiarize students with the results of experimental tests of economic theory. Requirement: Graduate or honors undergraduate, major standing, and permission of the departmental director of graduate study or course instructor.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ECON 5974:

Independent Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Independent Study

Instruction Type(s): Independent Study

Prerequisite(s):

Corequisite(s):

ECON 5984:

Special Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ECON 5994:

Research and Thesis

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research

Instruction Type(s): Research

Prerequisite(s):

ECON 6004:**Strategic Behavior**

Emphasizes strategic behavior in the presence of multiple decision makers. Game theory deals with strategic interaction and provides the formal framework to describe and analyze situations with conflicting interests--as well as situations with both common and conflicting interests. Proof of applicability is provided by means of numerical examples and real life cases, e.g., bargaining, contract theory, economic policy games, and voting.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): (ECON 5005 (UG), ECON 5006 (UG)) OR (ECON 5005, ECON 5006)

Corequisite(s):

ECON 6014:**Behavioral Economic Theory**

Psychological, social, and cognitive factors in economic decisions. Topics include risk and ambiguity, intertemporal choice and self-control, bounded rationality, heuristics, emotions, social norms, social preferences, learning, attention, and inference. Applications include contracting, bargaining, labor, development, industrial organization, finance, and macroeconomics.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECON 5006

Corequisite(s):

ECON 6024:**Advanced Topics in Econometrics Theory**

This course assumes a basic understanding of multiple regression and simultaneous equations modeling and introduces students to advanced econometric techniques commonly used in empirical work. These techniques include linear time series modeling in the time domain, discrete choice models, and panel data methods.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECON 5126 (UG) OR ECON 5126

Corequisite(s):

ECON 6054:**Development Economics**

A modern approach to economics of growth and development for graduate students in economics and related disciplines. Topics include sources of growth; neo-classical, endogenous, and dualistic theories of growth; households economics and human capital accumulation; economics of population; and consequences of imperfect market for land, labor and capital.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): (ECON 3104 (UG), ECON 3204 (UG)) OR (ECON 3104, ECON 3204)

Corequisite(s):

ECON 6104:**Labor Economics**

Labor demand and supply, investment in human capital, discrimination in the labor market, and the theory of equalizing wage differentials; search and unemployment, unions, and income distribution.

Credit Hour(s): 4

Lecture Hour(s): 4

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECON 5005 (UG) OR ECON 5005

Corequisite(s):

ECON 6204:**Public Economics**

This course describes the theory of government expenditures, stressing market failure as the rationale for government activity. The course describes the normative outcome achieved by a benevolent government, and the positive outcome achieved under rules of collective choice. Tax policy for different levels of government and selected topics in state and local public finance are also addressed.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): (ECON 5005 (UG), ECON 5006 (UG)) OR (ECON 5005, ECON 5006)

Corequisite(s):

ECON 6404:**Industry Structure**

market equilibrium, and on economic welfare. Problems of oligopolistic industries and analysis of government policies (regulation, anti-trust).

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECON 5005 (UG) OR ECON 5005

Corequisite(s):

ECON 6554 (AAEC 6554):

Panel Data Econometrics

Introduction to major panel data techniques and modeling ideas currently employed (e.g., dynamic panel, panel for discrete choice model, treatment effect and program evaluations etc.), including both statistical theory derivations and practical applications.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): (AAEC 5125 OR ECON 5125), AAEC 5126

Corequisite(s):

ECON 6564 (STAT 6564) (AAEC 6564):

Bayesian Econometric Analysis

Bayesian estimation of economic models, with focus on Gibbs sampling, hierarchical modeling, data augmentation, and model search. Strong emphasis on programming and computational implementation.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): AAEC 5126 OR ECON 5126 OR STAT 5304 OR STAT 5444

Corequisite(s):

ECON 6604:

Advanced Methods in Applied Microeconomics

Specification and estimation of static, dynamic oligopoly models, application of these models to the study of entry and market structure, vertical relationships, and collusion. Empirical application of auction models to economic development and to public finance.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECON 5005

Corequisite(s):

ECON 6614:

Philosophical Foundations of Econometrics

The philosophical and methodological problems underlying econometric modeling and inference. Topics include the distinction between statistical and substantive significance, the proper interpretation of inference p-values, data mining, and other issues related to reliable inference and learning from data.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECON 5125

Corequisite(s):

ECON 6984:

Special Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ECON 6994:

Research Seminar

Review and discussion of current research in economics by students, faculty members, and guest speakers. This course may be repeated for a maximum of 6 credits. Students are required to have Doctoral Standing in Economics.

Credit Hour(s): 1

Lecture Hour(s): 1

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ECON 7994:

Research and Dissertation

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research

Instruction Type(s): Research

Prerequisite(s):

105 Corequisite(s):

GEOSCIENCES

Steven Holbrook, Head

Emeriti Faculty: Gerald Gibbs; Michael Hochella; James Read; Akhaury Sinha; J Snoke;

Professors: Robert Bodnar; Thomas Burbey; Patricia Dove; Kenneth Eriksson; Steven Holbrook; John Hole; Scott King; Richard Law; Nancy Ross; Madeline Schreiber; James Spotila; Robert Weiss; Shuhai Xiao;

Associate Professors: Mark Caddick; Benjamin Gill; Frederick Michel; Brian Romans; Manoochehr Shirzaei; Ying Zhou;

Assistant Professors: Megan Duncan; Cristina Dura; Sterling Nesbitt; Ryan Pollyea; D Stamps; Michelle Stocker;

Adjunct Professors: Eileen Martin; Mitsuhiro Murayama; Philip Prince;

University Distinguished Professor: Robert Bodnar; Patricia Dove; Gerald Gibbs; Michael Hochella;

Collegiate Associate Professors: John Chermak;

Research Professors: Martin Chapman;

Senior Instructors: Neil Johnson;

Research Scientists: Sean Bemis; Luca Fedele; Lowell Moore; Rachel Reid; Vicki Yarborough;

Research Associate Professors: Susanna Werth;

Graduate Contact: apriln@vt.edu

Department Site: <http://www.geos.vt.edu>

Virginia Tech's Department of Geosciences focuses on research, education and outreach dealing with the nature of the earth. We offer the MS and PhD degree programs at the Blacksburg campus. Our students and faculty investigate earth processes at scales that range from atomic to planetary. We encourage interdisciplinary approaches to research in the geosciences, both within the department and through interdepartmental programs. More details about the department, faculty, and research programs can be found at <http://www.geos.vt.edu/>. We encourage prospective students to fill out a pre-application survey and to contact individual faculty to explore research opportunities.

SPECIAL FACILITIES

The Department of Geosciences is currently housed in Derring Hall. (See https://geos.vt.edu/research/Research_Facilities.html for more details on our Derring laboratory and research space.)

Geosciences Research Facilities

Aqueous Geochemistry Laboratory Biogeochemistry of Earth Processes (BGEP) Laboratory Chemical Hydrogeology Laboratory Bone Histology and Thin Section Laboratory Derring Electron Beam Laboratory (Cameca SX50 Electron Microprobe and Camscan Series II SEM) Exploration Geophysics Field Equipment Laboratory Extant Comparative

Laboratory Fluids Research Laboratory Fossil Preparation Laboratory Fossil Visualization Laboratory Geochemical Sample Preparation Clean Laboratory Geophysics Computing Facilities Geothermal Database Hydrothermal Synthesis and Experiment Laboratories Laser-Ablation ICPMS Laboratory Light Stable Isotope Laboratory Micropaleontology Laboratory Lithospheric Dynamics and Tectonophysics Laboratory Nanogeochemistry, Mineral Surface Geochemistry, and Biogeochemistry Laboratory Optical Microscopy and Digital Photomicrography Laboratory Physical Hydrogeology Laboratory Radiogenic Helium Laboratory Sedimentology and Stratigraphy Laboratory Structural Geology Laboratory Vibrational Spectroscopy Laboratory Virginia Tech Seismological Observatory X-ray Diffraction Laboratory X-ray Fluorescence Laboratory Cameca IMS-7F-GEO Secondary Ion Mass Spectrometer (SIMS) Laboratory (Geosciences Dept. facility housed in the Nanoscale Characterization and Fabrication Laboratory in the Institute for Critical Technology and Applied Science, Corporate Research Center) Cameca SX50 Electron Microprobe (Geosciences Dept. facility housed in the NCFL Laboratory of the Institute for Critical Technology and Applied Science, CRC) ICTAS/NCFL Facility (use available to Geosciences personnel): Dual-Beam FIB, ESEM, EBSD- and EDS-equipped SEMs and multiple TEMs in the Nanoscale Characterization and Fabrication Laboratory in the Institute for Critical Technology and Applied Science, CRC (<https://www.ncfl.ictas.vt.edu/>)

DEGREES OFFERED

MS Degree

Offered In (Blacksburg)

TOEFL

Computer: (250.0)

iBT: (80.0)

Paper: (600.0)

IELTS

General Test: (6.5)

The M.S. student must pass a minimum of 30 credit hours, at least 20 of which must be taken as coursework, and at least 6 must be research credits. The final exam for the M.S. degree is a defense of the thesis. The GRE is no longer required. Virginia Tech will accept IELTS scores of 6.5 or higher in lieu of the TOEFL.

PhD Degree

Offered In (Blacksburg)

TOEFL

Paper: (600.0)

Computer: (250.0)

iBT: (80.0)

IELTS

General Test: (6.5)

Ph.D. students must pass a minimum of 90 credit hours, at least 30 of which must be taken as coursework, and at least 30 must be research credits. The department does not give a standardized qualifying exam, but Ph.D. students must take a preliminary exam. The Ph.D. advisory committee shall have responsibility for the make-up and administration of the exam. The exam shall include both an oral and a written portion. Regulations that apply for the exam are: (1) the examination must be taken at least six months before the thesis/dissertation defense, and (2) at least 24 hours of coursework and/or research must remain to be taken at the time of the examination, including work for which the student is currently enrolled. It is recommended that the student meet with his/her advisory committee prior to preparing the exam to discuss the nature of the exam and the evaluation process. The final exam for the Ph.D. degree is a defense of the dissertation. The GRE is no longer required. Virginia Tech will accept IELTS scores of 6.5 or higher in lieu of the TOEFL.

GRADUATE COURSES (GEOS)

GEOS 5014:

Earth System History

Study of the evolution of the atmosphere, hydrosphere, biosphere, and geosphere. Emphasis will be given to the interactions among these components of the Earth system and how these interactions have shaped the history of the Earth.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

GEOS 5024:

Professional Development and Ethics in Geosciences

Skills for success in Geosciences, approaches to critical thinking, scientific communication, professionalism, ethical reasoning, safety in the lab and field, conflict resolution. Pass/Fail Only. Pre: Graduate Standing.

Credit Hour(s): 1

Lecture Hour(s): 1

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

GEOS 5084G:

Intermediate Geographic Information Systems

Use of automated systems for geographic data collection, digitization, storage, display and analysis in graduate research. Basic data flow in

GIS applications. Overview of GIS applications. Developing research methodology using GIS. Group projects to develop proficiency in the use of current GIS software. Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

GEOS 5124:

Geodynamics

Observations leading to the development of plate tectonics. Kinematics of plates on a sphere. Heat flow, mantle convection and viscous flow applied to solid planetary bodies. Graduate Standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

GEOS 5134:

Dynamics of Planetary Surface and Interiors

Structure and composition of the solar system as a constraint on planetary composition. Processes that shape and alter the surfaces and interiors of planets, moons, and asteroids including tectonics, volcanism, impact cratering, regolith formation, mass movement, and weathering. Effect of gravity, heat, pressure, and internal deformation on planets, moons, and asteroids. Derivation of mathematical models to represent surficial and internal deformation processes. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

GEOS 5144:

Inverse Theory and Geoscience Applications

Overview of inverse theory, utilizing geophysical examples to illustrate the concepts of model construction, parameter estimation, resolution, and non-uniqueness. Emphasis is on the linear problem, concluding with an overview of nonlinear inversion.

Credit Hour(s): 3

Lecture Hour(s): 3

107 Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

GEOS 5154:

Strong-Motion Seismology and Seismic Hazard Analysis

Introduction to the generation, propagation, measurement and prediction of strong ground motion from earthquakes, focusing on topics of importance to modern earthquake engineering. Effects of finite fault rupture, source directivity and Earth structure on the propagation of seismic waves; methods for developing ground motion time series for scenario earthquakes, statistical models of the earthquake recurrence process; probabilistic seismic hazard analysis. Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

GEOS 5204:

Terrigenous Depositional Systems

Bedforms and primary sedimentary structures, secondary sedimentary structures including trace fossils, facies, facies sequences, facies models, analysis of Holocene sedimentary environments, and paleoenvironmental interpretation of ancient sedimentary rocks, sedimentation and tectonics. Alternate years.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

GEOS 5214:

Carbonate Depositional Systems and Sequence Stratigraphy

Classroom, laboratory and field examination of the temporal and spatial makeup and controls on mineralogy and constituent composition of sedimentary carbonates, sequence stratigraphy of carbonate platforms, paleoclimatic significance of carbonates succession. Introduction to porosity evolution and cementation of carbonates in marine, meteoric and burial realms.

Credit Hour(s): 3

Lecture Hour(s): 2

Instruction Type(s): Lab, Lecture, Online Lecture

Instruction Type(s): Lab, Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

GEOS 5224:

Clastic Petrography and Diagenesis

Formation of terrigenous particles by weathering, clay mineralogy, clay diagenesis, tectonic control on framework grain composition, quartz arenites and silicretes, feldspathic sandstones, lithic sandstones, greywackes, and controls on sandstone diagenesis. Alternate years.

Credit Hour(s): 4

Lecture Hour(s): 3

Instruction Type(s): Lab, Lecture, Online Lecture

Instruction Type(s): Lab, Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

GEOS 5234G:

Advanced Vertebrate Evolution

Characterization of the evolution of vertebrates from the fossil record to now. Tracing anatomical features in humans to their origin of different vertebrate groups. Chronical vertebrate diversification events through extinctions, changes in climate in the last 600 million years, biogeography, and phylogenetic methods. Evidence of evolution through fossils and dissection. Pre: Graduate standing.

Credit Hour(s): 4

Lecture Hour(s): 3

Instruction Type(s): Lab, Lecture, VB, Online Lecture

Instruction Type(s): Lab, Lecture, VB, Online Lecture

Prerequisite(s):

Corequisite(s):

GEOS 5244:

Advanced Morphology of the Vertebrates

Identification of skeletal osteological elements of major groups of vertebrates, including aspects of skeletal functional morphology and homology, with emphasis on extant taxa. Skeletal systems of model and non-model organisms such as fish, amphibians, reptiles, birds, and mammals; specimen care and data management; modern skeletal collection practices. Pre: Graduate standing.

Credit Hour(s): 4

Lecture Hour(s): 3

Instruction Type(s): Lab, Lecture, VB, Online Lecture

Instruction Type(s): Lab, Lecture, VB, Online Lecture

Prerequisite(s):

Corequisite(s):

Advanced Earthquake Seismology

Seismicity and its causes in the context of plate tectonics; determination of earthquake location and mechanisms; seismogram (time series) analysis; theory of seismometers; hazard potential; wave propagation; use of earthquakes in determining earth structure. Graduate Standing required.

Credit Hour(s): 3

Lecture Hour(s): 2

Instruction Type(s): Lab, Lecture, Online Lecture

Instruction Type(s): Lab, Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

GEOS 5264:

Advanced Sedimentary Basins

Formation, evolution, and characterization of regions of the Earth's surface that experience long-lived subsidence and sediment accumulation. Integration of concepts and skills from: stratigraphy, surface processes, tectonics, structural geology, burial/thermal history, geo/thermochronology, and geodynamics; content is relevant to fields such as paleontology, (paleo)climatology, and subsurface resource management. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 2

Instruction Type(s): Lab, Lecture, VB, Online Lecture

Instruction Type(s): Lab, Lecture, VB, Online Lecture

Prerequisite(s):

Corequisite(s):

GEOS 5354G:

Advanced Remote Sensing

Theory and methods of remote sensing. Practical exercises in interpretation of aerial photography, satellite, radar, and thermal infrared imagery. Digital analysis, image classification, and evaluation.

Applications in earth sciences, hydrology, plant sciences, and land use studies. Field project and report. Review of current research literature.

Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 2

Instruction Type(s): Lab, Lecture, Online Lecture

Instruction Type(s): Lab, Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

GEOS 5404G:

Graduate Advanced Structure

Basic principles of rock behavior under applied, non-hydrostatic stress

(experimental and tectonic) and analysis of the geometrical patterns produced. Graduate students will undertake a more advanced independent research project. Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

GEOS 5424:

Structural Petrology

Examination of the processes by which rocks deform due to tectonic stresses, and recognition and interpretation of the microstructures that record these processes. Consent required. Alternate years. II

Credit Hour(s): 3

Lecture Hour(s): 2

Instruction Type(s): Lab, Lecture, Online Lecture

Instruction Type(s): Lab, Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

GEOS 5535 (CHEM 5525):

X-Ray Crystallography

5535: Provides a thorough grounding in the principles of the crystalline state including lattices and symmetry, leading to the formal description of structures and surfaces and the interpretation of published crystallographic data. 5536: Covers methods of single-crystal and powder X-ray diffraction for the determination of the atomic arrangement of atoms within crystalline materials.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

GEOS 5536:

X-RAY CRYSTALLOGRAPHY

5535: Provides a thorough grounding in the principles of the crystalline state including lattices and symmetry, leading to the formal description of structures and surfaces and interpretation of published crystallographic data. 5536: Covers methods of single-crystal and powder X-ray diffraction for the determination of the atomic arrangement of atoms within crystalline materials.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

GEOS 5634G:

Advanced Environmental Geochemistry

Application of quantitative methods of thermodynamic and physicochemical analysis to the study of the distribution and movement of chemical elements in surface and near-surface geological environments. Emphasis on using fundamental principles to understand natural systems and solve practical problems in environmental geochemistry. Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 2

Instruction Type(s): Lab, Lecture, Online Lecture

Instruction Type(s): Lab, Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

GEOS 5704:

Geochemical Thermodynamics

Fundamentals of chemical thermodynamics as applied to earth materials (solid, fluid and gaseous) over wide ranges of pressure and temperature.

Derivation of thermodynamic functions from the three laws of thermodynamics. The phase rule, phase equilibria, and Schreinemakers analysis. Comparison of the behavior of real and ideal systems.

Graduate Standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

GEOS 5714G:

Advanced Volcanic Processes

Study of characteristics and mechanisms of volcanic phenomena, including magma dynamics, origin and chemistry of lavas, physics of eruptions, and characteristics of volcanic products, particularly pyroclastic deposits. Includes focus on volcanism as a general planetary process, on terrestrial tectonic settings of volcanism and on volcanic hazards. Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

GEOS 5744:

Fluid Inclusions Techniques

The study of fluid inclusions in rocks and minerals from sedimentary, metamorphic, igneous, and ore-forming environments. Basic fluid inclusion principles and techniques and characteristics of inclusions from these various geologic environments will be described. Consent required.

Credit Hour(s): 3

Lecture Hour(s): 2

Instruction Type(s): Lab, Lecture, Online Lecture

Instruction Type(s): Lab, Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

GEOS 5754:

Fluids in the Earths Crust

The physical and chemical properties of various fluids of geologic interest and the interaction of these fluids with minerals, rocks, and melts in the earths crust are considered. Consent required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

GEOS 5804:

Quantitative Hydrogeology

Rigorous mathematical and physical concepts of fluid flow in porous geological media. The course will focus on the mechanics of groundwater flow in one, two, and three spatial dimensions. Boundary conditions and analytical solutions to subsurface and vadose-zone flow problems will be explored and solved analytically. The mechanics of horizontal and vertical deformation of aquifers due to applied pumping stress will be taught from first principles. Includes problems dealing with steady and transient groundwater flow, Biots equations and three-dimensional consolidation theory.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

GEOS 5804G:**Advanced Groundwater Hydrology**

Physical principles of groundwater flow, including application of analytical solutions to real-world problems. Well hydraulics. Geologic controls on groundwater flow. Graduate standing required.

Credit Hour(s): 0 OR 3

Lecture Hour(s): 0 OR 2

Instruction Type(s): Lab, Lecture, Online Lecture

Instruction Type(s): Lab, Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

GEOS 5814 (CEE 5354):**Numerical Modeling of Groundwater**

Theory and practice of numerical techniques are developed and applied to fluid flow and transport in ground-water flow systems. Governing equations are formulated using FD and FE techniques with appropriate BCs and ICs. Additional topics include: model conceptualization and grid design in multidimensional systems; practical applications of numerical models including calibration, validation, and prediction; concepts and techniques of advective transport using particle tracking and dispersive transport. Introduction to MODFLOW, MODPATH, MT3D, and others.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

GEOS 5834:**Chemical Hydrogeology**

Study of solute transport in geologic systems. Focus on processes of advection, dispersion, mineral dissolution and precipitation, chemical reactions and microbially-mediated reactions. Includes use of hydrogeochemical models to simulate chemical transport in geologic systems. Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

GEOS 5844 (GEOG 5134):**Advanced Interdisciplinary Issues and Ethics in Water Resources**

Issues and ethics related to water resources, water as a hazard upon human (infrastructure, economy) and ecological (rivers, groundwater)

systems, water- and vector-borne disease, climate change, dams, and eutrophication. Multidimensionality of water resources. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

GEOS 5924G:**Advanced Tectonics**

Overview of modern plate tectonic theory and history. Physical processes driving present-day plate tectonic deformation including continental rifts, rifted margins, continental transforms, strike-slip faults, subduction zones and orogenic belts. Plate kinematic concepts and information about the Earth's structure. Application of scientific method, data analysis, and computational modeling. Graduate standing.

Credit Hour(s): 4

Lecture Hour(s): 3

Instruction Type(s): Lab, Lecture, VB, Online Lecture

Instruction Type(s): Lab, Lecture, VB, Online Lecture

Prerequisite(s):

Corequisite(s):

GEOS 5974:**Independent Study**

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Independent Study

Instruction Type(s): Independent Study

Prerequisite(s):

Corequisite(s):

GEOS 5984:**Special Study**

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

GEOS 5994:**Research and Thesis**

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research

Instruction Type(s): Research

Prerequisite(s):

Corequisite(s):

GEOS 6104:

Advanced Topics in Geophysics

Advanced analysis of one or more topics of geophysics using the most recent techniques, interpretations, and data. Can be taken up to three times provided the subject material is different. Consent required.

Alternate years.

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

GEOS 6204:

Advanced Topics in Sedimentology

Advanced analysis of one or more topics in sedimentology using the most recent techniques, interpretations, and data. Can be taken up to three times provided the subject material is different. Consent required.

Alternate years.

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

GEOS 6304:

Advanced Topics in Paleontology

Advanced analysis of one or more topics in paleontology using the most recent techniques, interpretations, and data. Can be taken up to three times provided the subject material is different. Consent required.

Alternate years.

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

GEOS 6404:

Advanced Topics in Structure/Tectonics

Current ideas and research problems in structural geology and tectonics. Can be taken up to three times provided the subject material is different.

Consent required. Alternate years.

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

GEOS 6504:

Advanced Topics in Mineralogy

Current research in the major mineral groups subdivided by crystallographic, crystal chemical, or petrogenetic affinities. May be repeated up to three times. Alternate years.

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

GEOS 6604:

Advanced Topics in Geochemistry

Advanced analysis of one or more topics of geochemistry using the most recent techniques, interpretations, and data. Can be taken up to three times provided the subject material is different. Consent required.

Alternate years.

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

GEOS 6704:

Advanced Topics in Petrology

Advanced analysis of one or more topics of petrology using the most recent techniques, interpretations, and data. Can be taken up to three times provided the subject material is different. Consent required.

Alternate years.

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

112 Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

GEOS 6984:

Special Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

GEOS 7994:

Research and Dissertation

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research

Instruction Type(s): Research

Prerequisite(s):

Corequisite(s):

MATHEMATICS

Eric De Sturler, Chair

Professors: Slimane Adjerid; Christopher Beattie; Jeffrey Borggaard; John Burns;

Eric De Sturler; Alexander Elgart; Mark Embree; Serkan Gugercin; Peter Haskell;

Terry Herdman; Traian Iliescu; Jong Kim; Martin Klaus; Tao Lin; Peter Linnell;

Nicholas Loehr; Gretchen Matthews; Anderson Norton; Michael Renardy; Robert

Rogers; John Rossi; Mark Shimozone; Shu Ming Sun; James Turner; Timothy

Warburton;

Associate Professors: Julianne Chung; Matthias Chung; Mihaela Ciupe;

Constantin Mihalcea; Peter Wapperom; Megan Wawro; Pengtao Yue; Lizette

Zietsman;

Assistant Professors: Lauren Childs; Russell Hewett; Estrella Johnson; Honghu

Liu; Eileen Martin; Travis Morrison; Daniel Orr; Eyvindur Palsson; Omar Saucedo;

Wenbo Sun; Yun Yang;

Affiliated Faculty: Lara Anderson; James Gray; Catherine Ulrich; Jesse Wilkins;

Hatcher Professor of Mathematics: John Burns;

Virginia Tech Class of 1950 Professor: Serkan Gugercin; Michael Renardy;

Luther and Alice Hamlett Professor: Mark Embree;

John K. Costain Faculty Chair: Timothy Warburton;

Hamlett Junior Faculty Fellow: Lara Anderson;

General Contact: info@math.vt.edu

Graduate Site: https://www.math.vt.edu/content/math_vt_edu/en/grad-math.html

Student Handbook:

https://www.math.vt.edu/content/dam/math_vt_edu/documents/grad-policies.pdf

The Department of Mathematics offers programs leading to M.S. and Ph.D. degrees. Both traditional and interdisciplinary options are available for the M.S. degree. Details about the M.S. and Ph.D. degree options can be found in our graduate program policies document available at https://www.math.vt.edu/content/dam/math_vt_edu/documents/grad-policies.pdf. The department has internationally recognized excellence in the areas of algebra and combinatorics, algebraic geometry and topology, computational science, continuous and discrete dynamical systems, control theory and optimization, fluid dynamics, math education, mathematical biology and mathematical physics, number theory, numerical analysis, and partial differential equations. This research is supported by collaborations with researchers across Virginia Tech either in other departments or in various centers and institutes. These include, among others, the Center for Mathematical Computation (CMC), the Interdisciplinary Center for Applied Mathematics (a University research center), and the Biocomplexity Institute of Virginia Tech. Please visit the Department of Mathematics at <https://www.math.vt.edu/> for more information.

SPECIAL FACILITIES

Students on assistantship are allocated office space in the department and offices are made available to those students not on assistantship as space allows. All students have access to a well-equipped graduate computer laboratory and students may use a departmental cluster.

DEGREES OFFERED

MS Degree

Offered In (Blacksburg)

TOEFL

Paper: (550.0)

Computer: (213.0)

iBT: (80.0)

GRE

General Test: Verbal, Quantitative, Analytical

The M.S. degree is designed to be completed in two years of graduate study. Thesis and non-thesis options are available for the M.S. degree. In the thesis option the student writes and defends a Master's Thesis under the direction of a faculty member. The time spent preparing the thesis is represented by 6 to 9 hours of MATH 5994 (Research and Thesis) among the required courses. The department also offers a special interdisciplinary plan for either the thesis or non-thesis M.S. degrees. This plan is intended for students having clearly defined, interdisciplinary career goals. Additional flexibility in the formal requirements allows the student's advisory committee to customize a Plan of Study to the student's goals. It must be emphasized that the interdisciplinary plan is intended only for students who enter the graduate program with specific, interdisciplinary career objectives. The student desiring studies under this plan needs to take the initiative to develop an appropriate Plan of Study at the very outset of their graduate studies. Hour requirements: for any of the degree options, the student's

Plan of Study must show 30 hours. The courses which make up these 30 hours must meet the constraints indicated in "Policies and Degree Requirements" https://www.math.vt.edu/content/dam/math_vt_edu/documents/grad-policies.pdf. (Transfer credit may be used for up to 50% of coursework numbered 5000 and higher, subject to the advisory committee's approval and Graduate School guidelines.)

PhD Degree

Offered In (Blacksburg)

TOEFL

Paper: (550.0)

Computer: (213.0)

iBT: (80.0)

GRE

General Test: Verbal, Quantitative, Analytical

The Ph.D. requires the completion of 90 hours, of which between 30 and 60 must be MATH 7994 (Research and Dissertation). At least 27 hours must be mathematics courses (excluding Research and Dissertation) numbered 5000 or higher. No more than 50% of the graded credit hours needed to satisfy the requirements for a Virginia Tech graduate degree may be transferred in from a regionally accredited university. All such credits must have earned grades of "B" or better, have been earned while in good standing in graduate status, and must have been graduate courses (numbered 5000 or higher) at the institution where the student took the courses. All transfer credit is subject to the advisory committee's approval and Graduate School guidelines. Courses used toward the M.S. in mathematics may be used toward the Ph.D. as well. More information about the specific requirements for the Ph.D. can be found in "Policies and Degree Requirements" at https://www.math.vt.edu/content/dam/math_vt_edu/documents/grad-policies.pdf.

GRADUATE COURSES (MATH)

MATH 5114:

Specialized Topics in Algebra

Various graduate level topics in algebra such as field theory, non-commutative ring theory, group representation theory, Lie algebras. May be taken for credit more than once with departmental permission.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): MATH 4124

Corequisite(s):

MATH 5125:

Abstract Algebra

Groups, rings and ideals, modules, brief introduction to homological algebra.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): MATH 4124

Corequisite(s):

MATH 5126:

Abstract Algebra

Groups, rings and ideals, modules, brief introduction to homological algebra.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): MATH 4124, MATH 5125

Corequisite(s):

MATH 5144:

Inverse Theory and Geoscience Applications

Overview of inverse theory, utilizing geophysical examples to illustrate the concepts of model construction, parameter estimation, resolution, and non-uniqueness. Emphasis is on the linear problem, concluding with an overview of nonlinear inversion.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): MATH 2214, MATH 2224

Corequisite(s):

MATH 5214:

Topics in Analysis

Topics in mathematical analysis. Algebraic structures in analysis. Function spaces. Approximation schemes. This course may be repeated for credit, without limit on the number of credits earned, if the topic subtitle is not repeated. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

MATH 5225:

Real Analysis

measure and integration, differentiation, applications to linear analysis.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): MATH 4226

Corequisite(s):

MATH 5226:

Real Analysis

Basic set theoretic and topological notions, fundamental theorems of measure and integration, differentiation, applications to linear analysis.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): MATH 4226, MATH 5225

Corequisite(s):

MATH 5235:

Complex Analysis

Holomorphic functions, complex integration and residues, series expansions, normal families and the Riemann mapping theorem, entire functions, power series in the unit disk.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): MATH 3224 OR MATH 4225

Corequisite(s):

MATH 5236:

Complex Analysis

Holomorphic functions, complex integration and residues, series expansions, normal families and the Riemann mapping theorem, entire functions, power series in the unit disk.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): MATH 3224 OR MATH 4225, MATH 5235

Corequisite(s):

MATH 5245:

Ordinary Differential Equations

Existence theorems, linear theory, stability theory, periodic solutions, Poincare-Bendixon theory, boundary-value problems, functional

differential equations.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): MATH 4225

Corequisite(s):

MATH 5246:

Ordinary Differential Equations

Existence theorems, linear theory, stability theory, periodic solutions, Poincare-Bendixon theory, boundary-value problems, functional differential equations.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): MATH 4225, MATH 5245

Corequisite(s):

MATH 5344:

Specialized Topics in Topology and Geometry

Various graduate level topics in topology and geometry. May be taken for credit more than once with department consent.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): MATH 4324

Corequisite(s):

MATH 5414:

Topics in Applied Mathematics

Various graduate level topics in applied mathematics such as discontinuous Galerkin methods for partial differential equations, stochastic differential equations and advanced partial differential equations. May be repeated with different topics and department consent. Pre: Graduate Standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

MATH 5424:

Matrix factorizations and iterative algorithms. Stability analysis, accuracy, and problem conditioning. Solving large systems of linear equations, linear least-squares, and eigenvalue problems. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

MATH 5425:

Applied Partial Differential Equations

Partial differential equations of first and second order, hyperbolic equations, elliptic equations and Greens functions, parabolic equations, canonic forms, application to physics and engineering.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): MATH 4426 OR MATH 4564

Corequisite(s):

MATH 5426:

Applied Partial Differential Equations

Partial differential equations of first and second order, hyperbolic equations, elliptic equations and Greens functions, parabolic equations, canonic forms, application to physics and engineering.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): MATH 4426 OR MATH 4564, MATH 5425

Corequisite(s):

MATH 5444:

Numerical Methods for Ordinary Differential Equations

Computational procedures for ordinary differential equations including Runge-Kutta methods, variable-step Runge-Kutta methods, predictor-corrector methods, applications to two-point boundary-value problems and parameter estimation. Error control, relative and absolute stability, methods for stiff equations; with computer assignments. Senior standing in engineering, science, or mathematics, and some programming ability required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

MATH 5454:

Graph Theory

Graphs, trees, connectivity, Euler tours, matching, independent sets and cliques, planar graphs, directed graphs. Consent required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

MATH 5464:

Combinatorics

Counting problems, generating functions, recurrence relations, principle of inclusion and exclusion, experimental designs. Consent required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

MATH 5465:

Numerical Analysis

A survey of the construction, analysis, and implementation of numerical algorithms in linear algebra, nonlinear equations and optimization, approximation by polynomials, quadrature, and ordinary differential equations. High-level programming language required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): MATH 4525

Corequisite(s):

MATH 5466:

Numerical Analysis

A survey of the construction, analysis, and implementation of numerical algorithms in linear algebra, nonlinear equations and optimization, approximation by polynomials, quadrature, and ordinary differential equations. High-level programming language required.

Credit Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): MATH 4525, MATH 5465

Corequisite(s):

MATH 5474 (CS 5474):

Finite Difference Methods for Partial Differential Equations

Finite difference methods for initial and boundary value problems for partial differential equations. Consistency, stability, convergence, dispersion, and dissipation. Methods for linear and nonlinear elliptic and parabolic equations, first- and second-order hyperbolic equations, and nonlinear conservation laws. High-level programming language required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

MATH 5484 (CS 5484):

Finite Element Methods for Partial Differential Equations

Weak formulations of boundary-value problems for elliptic partial differential equations. Finite element spaces. Approximation theory for finite element spaces. Error estimates. Effects of numerical integration and curved boundaries. Nonconforming methods. Concrete examples of the application of the finite element method. Efficient implementation strategies. Time dependent problems. High-level programming language required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): MATH 3414, MATH 4525

Corequisite(s):

MATH 5485 (CS 5485):

Numerical Analysis and Software

Presentation and analysis of numerical methods for solving common mathematical and physical problems. Methods of solving large sparse linear systems of equations, algebraic eigenvalue problems, and linear least squares problems. Numerical algorithms for solving constrained and unconstrained optimization problems. Numerical solutions of nonlinear algebraic systems. Convergence, error analysis. Hardware and software influences. Efficiency, accuracy, and reliability of software. Robust computer codes.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): MATH 4445, MATH 4446

Corequisite(s):

MATH 5486 (CS 5486):

Numerical Analysis and Software

Presentation and analysis of numerical methods for solving common mathematical and physical problems. Methods of solving large sparse linear systems of equations, algebraic eigenvalue problems, and linear least squares problems. Numerical algorithms for solving constrained and unconstrained optimization problems. Numerical solutions of nonlinear algebraic systems. Convergence, error analysis. Hardware and software influences. Efficiency, accuracy, and reliability of software. Robust computer codes.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): MATH 4445, MATH 4446

Corequisite(s):

MATH 5515 (GBCB 5515):

Mathematical Methods for Modeling and Simulation of Biological Systems

Introduction to mathematical techniques for modeling and simulation, parameter identification and analysis of biological systems. Emphasis on both theoretical and practical issues and methods of computation, with concrete applications. Suitable for students from the mathematical and life sciences who have a basic foundation in multivariate calculus and ordinary differential equations. 5515: Continuous models and methods. 5516: Discrete models and methods.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

MATH 5516:

Mathematical Methods for Modeling and Simulation of Biological Systems

Introduction to mathematical techniques for modeling and simulation, parameter identification and analysis of biological systems. Emphasis on both theoretical and practical issues and methods of computation, with concrete applications. Suitable for students from the mathematical and

ordinary differential equations. 5515: Continuous models and methods.
5516: Discrete models and methods.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

MATH 5524:

Matrix Theory

Determinants, rank, linear systems, eigenvalues, diagonalization, Gram-Schmidt process, Hermitian and unitary matrices, Jordan canonical form, variational principles, perturbation theory, Courant minimax theorem, Weyls inequality, numerical methods for solving linear systems and for determining eigenvalues. science or engineering.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

MATH 5545:

Calculus of Variations and Optimal Control Theory

Unified course in the calculus of variations and control theory including multiple integral problems and distributed parameter control systems.

Necessary conditions, sufficient conditions, nonclassical problems, optimal control, distributed parameter control, computational methods.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): MATH 4525, MATH 4425

Corequisite(s):

MATH 5546:

Calculus of Variations and Optimal Control Theory

Unified course in the calculus of variations and control theory including multiple integral problems and distributed parameter control systems.

Necessary conditions, sufficient conditions, nonclassical problems, optimal control, distributed parameter control, computational methods.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): MATH 4525, MATH 4425, MATH 5545

Corequisite(s):

MATH 5554:

Approximation Theory

Algorithms for calculating the best approximations in the uniform norm and in inner-product spaces. Weierstrass and Jackson theorems.

Lagrange and Hermite interpolation. Function approximation by piecewise and rational polynomial approximation. Approximation of linear functionals including numerical differentiation and numerical integration rules. Applications include numerical methods for approximating solutions to differential equations and linear systems theory. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

MATH 5564:

Model Reduction: System-Theoretic Methods

Transfer functions, reachability and observability, Gramians. Balanced truncation. Interpolatory model reduction and optimal interpolation. Data-driven modeling. Parametric Systems. Balanced truncation for nonlinear systems. Interpolatory model reduction for nonlinear systems. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

MATH 5614 (EDCI 5614):

Topics for In-Service Teachers

Various topics in mathematics and its applications to real-life problems, presented in light of contemporary instructional technologies and standards of learning. The course is designed for in-service mathematics teachers at the high and middle school levels and is suitable for recertification credit. The specific topics covered will be tailored to the location and delivery mode of the course, as well as evolving standards and methodology. May be repeated for credit with different content. May not be applied toward graduate degrees in mathematics. In-service status required.

Credit Hour(s): 3

Lecture Hour(s): 3

118 Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

MATH 5624:

Research on Mathematical Knowing and Learning

Methods for conducting scientific research on how K-12 students learn mathematics. Students will develop skills for designing and conducting such research across various domains of mathematical learning, such as whole numbers, fractions, algebra, and calculus. Pre: Graduate Standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

MATH 5634:

Research in Undergraduate Mathematics Education

Research on undergraduate mathematics education. Student understanding of particular concepts from undergraduate math courses, from calculus to abstract algebra. Student engagement in mathematical practices, such as proving and defining, that transcend particular course concepts. Pre: Graduate Standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

MATH 5974:

Independent Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Independent Study

Instruction Type(s): Independent Study

Prerequisite(s):

Corequisite(s):

MATH 5984:

Special Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

MATH 5994:

Research and Thesis

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research

Instruction Type(s): Research

Prerequisite(s):

Corequisite(s):

MATH 6255:

Functional Analysis

Banach spaces, Hilbert spaces, linear operators on Banach and Hilbert spaces, Riesz Representation Theorems, spectral theory, topological vector spaces, other topics in functional analysis.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): MATH 5226

Corequisite(s):

MATH 6256:

Functional Analysis

Banach spaces, Hilbert spaces, linear operators on Banach and Hilbert spaces, Riesz Representation Theorems, spectral theory, topological vector spaces, other topics in functional analysis.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): MATH 5226, MATH 6255

Corequisite(s):

MATH 6324:

Topics in Topology and Geometry

Advanced topics in topology and geometry. May be taken for credit more than once with department consent, with different content.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

119 Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): MATH 5344

Corequisite(s):

MATH 7994:

Research and Dissertation

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research

Instruction Type(s): Research

Prerequisite(s):

Corequisite(s):

PHYSICS

Mark Pitt, Chair

Professors: Nahum Arav; Lay Chang; Sophia Economou; James Heflin; Jean Heremans; Patrick Huber; Giti Khodaparast; Jonathan Link; Djordje Minic; Pendleton Montague; Seong Mun; Kyungwha Park; Leo Piiilonen; Mark Pitt; Michel Pleimling; Eric Sharpe; John Simonetti; Uwe Tauber; Robert Vogelaar;

Associate Professors: Lara Anderson; Edwin Barnes; Shengfeng Cheng; James Gray; Shunsaku Horiuchi; Camillo Mariani; Vinh Nguyen; Hans Robinson; Vito Scarola; Victoria Soghomonian; Tatsu Takeuchi;

Assistant Professors: Rana Ashkar; Satoru Emori; Cihan Kaplan; ; Marie Boer; Thomas O'Donnell; Tudor-Alexandru Petrescu; Ian Shoemaker;

Research Faculty: Ibrahim Ozcan; Kenneth Wong;

Adjunct Professors: Zheng Chang; Yi-Gao Liang; Ganapati Myneni; Zoltan Toroczka;

Affiliated Faculty: Levon Asryan; Louis Guido; Alexey Onufriev; Mark Paul; Chenggang Tao;

Roger Moore and Mojdeh Khatam-Moore Faculty Fellow: Patrick Huber;

L.C. Hassinger Faculty Fellow: Giti Khodaparast;

William E. Hassinger, Jr., Senior Faculty Fellow in Physics: Sophia Economou;

Graduate Contact: gradphys@vt.edu

Graduate Program Coordinator: bewilki2@vt.edu

Graduate Site: <https://www.physics.vt.edu/Graduate/GraduateProgram.html>

Student Handbook:

https://www.physics.vt.edu/content/dam/physics_vt_edu/graduateprogramdocuments/GraduateHandbook2017.pdf

The Department of Physics offers program coursework and research leading to M.S. (thesis optional) and Ph.D. degrees. Details about the M.S. and Ph.D. degree options can be found in our graduate program policies document available at <https://www.physics.vt.edu/Graduate/GraduateProgram.html> The

Department has internationally recognized excellence in experimental and/or theoretical aspects of astronomical, biological, condensed matter, nuclear, and particle physics. This research is supported by collaborations with researchers across Virginia Tech and at outside institutions of higher learning. Please visit the Department at <https://www.physics.vt.edu/Research.html/> for more information.

SPECIAL FACILITIES

Experimental laboratories within the Department of Physics include facilities employing Raman scattering, far-infrared to near-ultraviolet spectroscopy, conventional and superconducting magnets, thin-film electron scattering, susceptometry, sol-gel studies, laser holography and spatial filtering, and pulsed laser nonlinear optical measurements such as harmonic generation and degenerate four-wave mixing, and clean-room. Other techniques and materials are available via collaborative programs with the Departments of Chemistry, Chemical Engineering, and Materials Science. Facilities are maintained in the Department of Physics to prepare experiments and analyze data collected by the radio astronomy and elementary particle groups which are currently working at national and international research centers, including FermiLab (FNAL, Illinois), Brookhaven National Laboratory (BNL, New York), Thomas Jefferson National Accelerator Facility (TJNAF, Virginia), Oak Ridge National Laboratory (ORNL, Tennessee), Laboratori Nazionali del Gran Sasso (LNGS, Italy), Kou Enerugii Kasokukikenkyuukikou (KEK, Japan), Los Alamos National Laboratory (LANL, New Mexico), Kimballton underground science and engineering facility (Virginia), and National Radio Astronomy Observatory (NRAO, including the VLA and VLBA). Housed in the department is the university's Center for Neutrino Physics (CNP), as well as the Center for Soft Matter and Biological Physics. Virginia Tech university computing offers multiple high-performance computing systems. The Physics department has two dedicated clusters and a distributed collection of about 200 limited-availability nodes, all running Linux. Access to supercomputers is available through national and international networks. The Physics department operates a professional machine shop, a computer shop, and a student shop.

Physics Facilities

The faculty in Virginia Tech's Physics Department conducts research in astronomical, mathematical, medical, nuclear, elementary particle, and condensed-matter physics. Medical and neuroscience research is conducted at sites in Arlington and Roanoke, Virginia. Much of the research activity in astronomy and experimental nuclear and particle physics utilizes off-campus facilities, while most of the instrumentation and data analysis are performed on-campus. These facilities include Brookhaven National Laboratory, Daya Bay, Fermilab, KEK, LANL, ORNL, TJNAF, NRAO, Gran Sasso, and the nearby Kimballton Underground Research Facility (KURF). Telescopes used by the astronomy group include the Hubble Space Telescope, the Very Large Telescope, the Chandra X-ray satellite, the Spitzer IR satellite, and the XMM-Newton X-ray satellite. Experimental facilities in condensed-matter physics include low-temperature facilities and variable-temperature high-magnetic-field magneto-transport systems, low-temperature optical systems, pulsed near- and mid-infrared lasers, visible-ultraviolet lasers, spectrometers, confocal microscopy and related optical characterization facilities, nanofabrication systems, thin-film materials deposition

systems, materials synthesis, room-temperature and low-temperature scanning tunneling microscopy, and various other microscopy systems. More analytical and nanofabrication systems (e.g., X-ray, Auger, TEM, AFM, SIMS, SQUID, and FIB) are housed in on-campus facilities. Research is also performed off-campus, for example, at the National High Magnetic Field Laboratory. Housed in Robeson Hall is the University's Center for Neutrino Physics (CNP). Many theorists are members of the University Center for Statistical Mechanics, Mathematical Physics, and Theoretical Chemistry, composed of faculty from the Departments of Chemistry, Physics, and Mathematics. The Department of Physics is also home to the Center for Soft Matter and Biophysics at Virginia Tech. This interdisciplinary research Center was established in February 2016, and is administered by the Department of Physics in the College of Science. Its mission is to advance the rapidly growing research areas of soft matter and biological physics. Special attention will be extended to how these developments can address many of the most significant problems currently facing society, for example effective drug design and delivery, next generation materials, programmable biology, and models for human disease. Virginia Tech University computing offers multiple high-performance computing systems. The Physics Department has two dedicated clusters and a distributed collection of about 200 limited-availability nodes, all running Linux. Access to supercomputers is available through national and international networks. The Physics Department operates a professional machine shop, a computer shop, and a student shop.

DEGREES OFFERED

MS Degree

Offered In (Blacksburg)

TOEFL

Paper: (600.0)

Computer: (250.0)

iBT: (90.0)

GRE

General Test: Verbal, Quantitative, Analytical

GRE

Subject: Physics

Degree requirements include courses, both required and elective, and a qualifying examination. There are two options, thesis and non-thesis, both of which require 32 credit hours of coursework. Thesis Master's students must also write and defend a thesis, roughly comparable to a prelim exam.

PhD Degree

Offered In (Blacksburg)

TOEFL

Paper: (600.0)

Computer: (250.0)

iBT: (90.0)

GRE

General Test: Verbal, Quantitative, Analytical

GRE

Subject: Physics

Degree requirements include courses, both required and elective, dissertation research, and examination(s). The credit requirement for a Ph.D. is 92 hours, including a minimum of 60 hours of research and dissertation, plus 32 hours of coursework. Ph.D. students are required to attempt a qualifying exam by the end of their third semester, and a prelim exam by the end of their fifth semester.

GRADUATE COURSES (PHYS)

PHYS 5254G:

Advanced Quantum Info Tech

Quantum computing and other quantum information technologies.

Differences between bit and qubit. Quantum logic gates, concept of entanglement, quantum teleportation, quantum cryptography and key distribution, quantum computing algorithms, including Deutsch-Jozsa algorithm, Grover's search algorithm, Shor's factoring algorithm. Basics of public-key cryptosystems and number theory as needed to present Shor's algorithm. Errors in a quantum computer and quantum error correction. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PHYS 5354:

Classical Mechanics

Theory of classical Lagrangian and Hamiltonian mechanics of particles and rigid bodies, including canonical transformations and Hamilton-Jacobi theory. Consent required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PHYS 5405:

Classical Electromagnetism

121 Classical theory of electromagnetism and its applications. 5405:

Electrostatics and magnetostatics; Maxwells equations and electromagnetic waves; wave guides, apertures, and antennae. 5406: Special relativity and Lagrangian and Hamiltonian formulations; Lienard-Wiechert potentials, motion, radiation, and energy loss be charged particles; self-fields and radiative damping; magnetic monopoles and field theories. Consent required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s): PHYS 5714

PHYS 5406:

Classical Electromagnetism

Classical theory of electromagnetism and its applications. 5405:

Electrostatics and magnetostatics; Maxwells equations and electromagnetic waves; wave guides, apertures, and antennae. 5406:

Special relativity and Lagrangian and Hamiltonian formulations; Lienard-Wiechert potentials, motion, radiation, and energy loss be charged particles; self-fields and radiative damping; magnetic monopoles and field theories. Consent required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): PHYS 5405

Corequisite(s): PHYS 5714

PHYS 5455:

Quantum Mechanics

General principles of nonrelativistic quantum mechanics from the point of view of advanced dynamics, with applications to problems of atomic and nuclear structure. Consent required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PHYS 5456:

Quantum Mechanics

General principles of nonrelativistic quantum mechanics from the point of view of advanced dynamics, with applications to problems of atomic and nuclear structure. Consent required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): PHYS 5455

Corequisite(s):

PHYS 5504:

Nuclear and Particle Physics

Properties of nuclei, two-nucleon systems, nuclear force, nuclear models, nuclear reactions, alpha and beta decay, and fission. Relativistic kinematics, invariance principles, quantum numbers, strange particles, weak interactions, formation and production reactions, and symmetries.

Consent required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PHYS 5555:

Solid-State Physics

Solidity, crystal structure, k-space, quantum mechanics of covalent bonding, phonon excitations, thermal energy, the nearly-free-electron approximation, Bloch electrons, E(k) energy bands in semiconductors and metals, density of states, optical properties of solids, donors and acceptors in semiconductors, excitons, plasmons, polaritons, electrical properties, magnetic materials, the percolation model and phase transitions, metal-insulator transitions, and amorphous solids. Consent required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PHYS 5556:

Solid-State Physics

Solidity, crystal structure, k-space, quantum mechanics of covalent bonding, phonon excitations, thermal energy, the nearly-free-electron approximation, Bloch electrons, E(k) energy bands in semiconductors and metals, density of states, optical properties of solids, donors and acceptors in semiconductors, excitons, plasmons, polaritons, electrical properties, magnetic materials, the percolation model and phase transitions, metal-insulator transitions, and amorphous solids. Consent required. I,II

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PHYS 5564G:

Advanced Polymer Physics

Introduction to the field of polymer physics. Statistical descriptions of polymers based on Brownian motion and random walk models.

Conformation of single chains. Thermodynamics of polymer mixtures, solutions, and melts. Properties of polymer networks. Polymer dynamics in both melt and solution states. Pre: Graduate Standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PHYS 5574G:

Intermediate Nanotechnology

Methods of controlling matter on the nanometer length scale and the applications thereof. Nanolithography, self-assembly, and scanned probe microscopy; nanomaterials including fullerenes, carbon nanotubes, and quantum dots; nanoscale and molecular electronics; nanoelectromechanical systems; nanoscale optoelectronics; and nanobiotechnology. Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PHYS 5614:

Introduction to Quantum Electronics

Theory of laser oscillation, optical resonators, interaction of radiation and atomic systems, giant pulsed lasers, laser systems, wave propagation in nonlinear media, modulation of optical radiation, noise in optical detection and generation, and interaction of light and sound. II

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): PHYS 4614

Corequisite(s):

PHYS 5614G:

Intermediate Optics

Fundamentals of the ray, wave and quantum models of light, and topics in modern optics with contemporary applications. Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PHYS 5654G:

Advanced Modern Cosmology

Survey of our current understanding of the origin, evolution, and fate of the Universe. Observational evidence behind the idea of the hot Big Bang, including the linear velocity-distance law, the existence of the cosmic microwave background, and the arguments for dark matter. Physics of a dynamic, expanding Universe via the Friedmann-Lemaitre-Robertson-Walker metric. Physical principles to determine the conditions in the early Universe, introducing the idea of inflation. Mechanisms driving the origin and evolution of galaxies and large-scale structures.

Pre: Graduate standing

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PHYS 5674G:

Intermediate General Relativity

Methods and applications of Einsteins general theory of relativity. Space and time and gravity in Newtonian physics; special theory of relativity; gravity as geometry of curved spacetime; black holes; cosmology; Einsteins gravitational field equations; gravitational waves and relativistic stars. Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

Statistical Mechanics

Theory of classical and quantum statistical mechanics. Derivation of thermodynamics. 5705: ensembles, fluctuations and ideal gas systems.

5706: modern developments and advanced topics.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): , PHYS 5456

Corequisite(s):

PHYS 5706:**Statistical Mechanics**

Theory of classical and quantum statistical mechanics. Derivation of thermodynamics. 5705: ensembles, fluctuations and ideal gas systems.

5706: modern developments and advanced topics.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): PHYS 5456, PHYS 5705

Corequisite(s):

PHYS 5714:**Methods of Theoretical Physics**

Selected topics in mathematical physics. Review of analytic function theory. Matrices, spectral theory of operators in Hilbert Space with applications to quantum mechanics. Solution of partial differential equations of mathematical physics, boundary-value problems, and special functions. Distribution theory and Greens functions. Consent required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PHYS 5714G:**Biophysics**

Selected topics from the general area of biomechanics, bioelectricity, radiation biophysics, molecular biophysics, and thermodynamics and transport in biological systems. Emphasis on the physical aspects of biological phenomena and biophysical measurement techniques and instrumentation. Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PHYS 5774G:**Advanced Physics of Galaxies**

Survey of our current observational and theoretical understanding of the formation and evolution of galaxies. Observational review of galaxy sizes and compositions, including the origin of the Hubble sequence. Physical description of a galaxy via distribution functions and stellar orbits. Time evolution of the distribution function. The Schwarzschild method for determining orbits. The physics of active galaxies. Pre: Graduate Standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PHYS 5794:**Computational Physics**

Survey of computational methods in physics. Applications of Fourier analysis, curve fitting, solving differential equations, solving integral equations, Monte Carlo simulations, symbolic mathematics, and graphic simulations in mechanics, electromagnetism, nuclear physics, atomic physics, molecular physics, and condensed matter physics.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): PHYS 4455

Corequisite(s):

PHYS 5894:**Final Examination**

NONE

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PHYS 5904:

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research

Instruction Type(s): Research

Prerequisite(s):

Corequisite(s):

PHYS 5944:

Seminar

May be repeated one time with different content for a maximum of 2 credits.

Credit Hour(s): 1

Lecture Hour(s): 1

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PHYS 5974:

Independent Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Independent Study

Instruction Type(s): Independent Study

Prerequisite(s):

Corequisite(s):

PHYS 5984:

Special Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PHYS 5994:

Research and Thesis

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research

Instruction Type(s): Research

Prerequisite(s):

Corequisite(s):

PHYS 6455:

Advanced Quantum Theory

Classical field theory; Noethers theorem and symmetries; second quantization and many-body formalism; free quantum Klein-Gordon, Dirac, and Maxwell fields; and interacting fields, S-matrix and covariant perturbation theory. Feynman diagrams; quantum electrodynamics; renormalization; path-integral formulation; non-Abelian gauge theories; and elements of electro-weak theory.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): PHYS 5354, PHYS 5406, PHYS 5456

Corequisite(s):

PHYS 6456:

Advanced Quantum Theory

Classical field theory; Noethers theorem and symmetries; second quantization and many-body formalism; free quantum Klein-Gordon, Dirac, and Maxwell fields; and interacting fields, S-matrix and covariant perturbation theory. Feynman diagrams; quantum electrodynamics; renormalization; path-integral formulation; non-Abelian gauge theories; and elements of electro-weak theory.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): PHYS 5354, PHYS 5406, PHYS 5456, PHYS 6455

Corequisite(s):

PHYS 6555:

Advanced Solid-State Physics

Applications of field-theory techniques to many-body aspects of solid-state physics. 6555: Green functions, Feynman diagrams, lattice Hamiltonian, neutron scattering, electron gas, Fermi-liquid theory, and linear-response theory. 6556: Electron-phonon interaction in metals and semiconductors, polarons, optical properties, excitons, superconductivity, and excitations in magnetic materials.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): PHYS 5456, PHYS 5555

Corequisite(s):

PHYS 6556:**Advanced Solid-State Physics**

Applications of field-theory techniques to many-body aspects of solid-state physics. 6555: Green functions, Feynman diagrams, lattice Hamiltonian, neutron scattering, electron gas, Fermi-liquid theory, and linear-response theory. 6556: Electron-phonon interaction in metals and semiconductors, polarons, optical properties, excitons, superconductivity, and excitations in magnetic materials.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): PHYS 5456, PHYS 5555

Corequisite(s):

PHYS 6675:**General Relativity and Cosmology**

6675: Differential geometry; equivalence principle; general theory of relativity; classical tests; post-Newtonian approximation; special solutions. 6676: Black holes; observational basis of cosmology; relativistic model universes; nucleosynthesis; cosmic background radiation; dark matter; inflation.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): PHYS 5354, PHYS 5406

Corequisite(s):

PHYS 6676:**General Relativity and Cosmology**

6675: Differential geometry; equivalence principle; general theory of relativity; classical tests; post-Newtonian approximation; special solutions. 6676: Black holes; observational basis of cosmology; relativistic model universes; nucleosynthesis; cosmic background radiation; dark matter; inflation.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): PHYS 5354, PHYS 5406

Corequisite(s):

PHYS 6714:**Selected Topics in Theoretical Physics**

Topics of current interest in theoretical physics as announced in Timetable. May be repeated for credit with permission. Consent

required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PHYS 6725:**Elementary Particle Physics**

Symmetry principles, quark model, scattering-theory and particle-theory processes, weak interactions, quantum chromodynamics, spontaneous symmetry breaking, and unified field theories. Consent required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s): PHYS 6455, PHYS 6456

PHYS 6726:**Elementary Particle Physics**

Symmetry principles, quark model, scattering-theory and particle-theory processes, weak interactions, quantum chromodynamics, spontaneous symmetry breaking, and unified field theories. Consent required. I,II

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): PHYS 6725

Corequisite(s): PHYS 6455, PHYS 6456

PHYS 6984:**Special Study**

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PHYS 7994:**Research and Dissertation**

NONE

Credit Hour(s): 1 TO 19

126 Lecture Hour(s):

Instruction Type(s): Research

Instruction Type(s): Research

Prerequisite(s):

Corequisite(s):

PSYCHOLOGY

Roseanne Foti, Chair

Emeriti Faculty: George Clum; Richard Winett;

Professors: Martha Ann Bell; Warren Bickel; Jack Finney; E Geller; Russell Jones;

Jungmeen Kim-Spoon; Thomas Ollendick; Angela Scarpa-Friedman; Robert

Stephens;

Associate Professors: Danny Axsom; Pearl Chiu; Rachel Diana; Julie Dunsmore;

Roseanne Foti; David Harrison; Neil Hauenstein; Brooks King-Casas; Robin

Panneton; John Richey; Bruce Scarpa-Friedman;

Assistant Professors: Rosanna Breaux; Charles Calderwood; Jorge Hernandez;

Tae-Ho Lee; Christina McDonnell; Kasey Stanton;

Research Faculty: Sharon Ramey; Craig Ramey;

Alumni Distinguished Professor: E Geller;

University Distinguished Professor: Thomas Ollendick;

Heilig Meyers Professor: Richard Winett;

Senior Instructors: Kurt Hoffman;

Research Assistant Professors: Vanessa Diaz;

Collegiate Assistant Professors: Andrea Pittarello;

General Contact: mwooddel@vt.edu

Graduate Site: <http://www.psyc.vt.edu/graduate>

The Department of Psychology at Virginia Tech offers a graduate program leading to the Ph.D. in four concentration areas: Biological Psychology, Clinical Science, Developmental Science, and Industrial/Organizational Psychology. Students earn a Master of Science (M.S.) degree in psychology en route to the Ph.D., but the department does not offer a terminal M.S. degree in any area. Applications from students with either bachelors or advanced degrees are welcomed. Although the graduate curriculum is organized into four specialty areas, all share the same philosophy: to assure that all graduate students are provided with the conceptual, quantitative, and methodological skills necessary to solve theoretical and applied problems. Application deadlines: December 1 for the Biological Psychology, Clinical Science, and Developmental Science concentration areas January 1 for the Industrial/Organizational Psychology concentration area

SPECIAL FACILITIES

Williams Hall is the on-campus home of the Department of Psychology, housing faculty and student offices, research labs, and classrooms. In addition, the department's off-campus Psychological Services Center and Child Study Center provide the foundation for practicum and research training and offer direct clinical services to children, adults, and families. Additional department resources include three state-of-the-art

laboratories dedicated to undergraduate and graduate teaching and research. The psychophysiological laboratory includes computer workstations, EEG/Evoked Potential workstations (including Neuroscan, Coulbourn, and BioPAC equipment), visual acuity and tracking equipment, as well as extensive perception equipment. The psychophysiology laboratory also houses the department's STISIM Drive fully-interactive driving simulator. The department also maintains a computer lab with 20 Dell Optiplex workstations for technology-assisted teaching and research with neurophysiological and cognitive experimental software, statistical analysis software, and data management programs. There is also a dedicated-research computer laboratory including 12 Dell Optiplex workstations with capabilities for running a variety of customized research software. Several faculty are affiliated with the Virginia Tech Carilion Research Institute (<http://info.vtc.vt.edu/phd/>), which offers world-class facilities for behavioral research, the world's premier human functional magnetic resonance imaging facility, and large-scale computational clusters for modeling, simulations, and analyses of large-scale molecular, genomic, biophysical, behavioral, imaging, and population-based data. The Institute also serves as the hub for a worldwide hyperscanning network for interactive, real-time functional brain imaging. Connecting the Institute's three research-dedicated magnetic resonance imaging scanners to multiple sites across the United States and throughout Europe and Asia, this network provides the world's first very-high-throughput functional brain imaging approach to the study of social cognition. This work is enabling new insights not only into how the brains of healthy children and adults make decisions, but also how traumatic brain injury, post-traumatic stress disorder, and a range of neuropsychiatric disorders affect critical decision-making processes.

DEGREES OFFERED

MS Degree

Offered In (Blacksburg)

TOEFL

Paper: (550.0)

Computer: (213.0)

iBT: (80.0)

GRE

General Test: Verbal, Quantitative, Analytical

M.S.: University minimums for research/thesis and non-thesis credit hours, plus additional specified courses and completion of a Thesis. We do not offer a terminal MS in any area, although students may earn an MS en route to the Ph.D. Details may be found in the student handbook at our website (<http://www.psyc.vt.edu/graduate>).

PhD Degree

Offered In (Blacksburg)

TOEFL

Paper: (550.0)

Computer: (213.0)

iBT: (80.0)

GRE

General Test: Verbal, Quantitative, Analytical

Ph.D.: University minimums for research/dissertation and non-dissertation credit hours plus additional specified courses and completion of a Preliminary Examination and Dissertation. Details may be found in the student handbook at our website (<http://www.psyc.vt.edu/graduate>).

GRADUATE COURSES (PSYC)

PSYC 5114:

Survey of Industrial-Organizational Psychology

Knowledge and skills to conduct job analyses, develop performance appraisal/management systems, develop psychological assessments, validate psychological assessments, assist organizations in avoiding violations of equal opportunity laws, develop programs to motivate employees, improve leadership skill and facilitate team effectiveness.

Pre: Graduate Standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PSYC 5274:

Personality Processes

Theory, research, and application in contemporary personality psychology.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PSYC 5284:

Psychopathology

Fundamental theory and research in the area of psychopathology. Emphasis on empirically derived theories and data concerned with assessment and description of psychopathological behavior.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PSYC 5294:

Psychophysiology

Intensive study of the distinct psychophysiological methodology and approach to the problem of physiological-behavioral correlation. Several primary areas of psychophysiology are presented: Autonomic-somatic integration and the measurement of psychophysiological activity, the orienting reflex and habituation, the psychophysiological correlates of learning, and patterning factors in psychophysiological response.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PSYC 5314:

Psychological Perspectives in Social Psychology

Examines reinforcement, field theoretic, cognitive, and role theory, and social learning theory and aggression, social exchange theories, social facilitation, group dynamics, attribution theory, environmental psychology, and impression management.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PSYC 5315:

Research Methods

Advanced treatment of a variety of research related issues germane to the discipline of psychology, including: the scientific method, elements of the research process, alternative strategies for operationalizing variables, sampling, research ethics, experimental research, quasi-experimental research, non-experimental research, research artifacts, non-traditional research strategies, quantitative literature reviews, and legal problems in research.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PSYC 5316:

Research Methods

Advanced treatment of a variety of research related issues germane to the discipline of psychology, including: the scientific method, elements of

the research process, alternative strategies for operationalizing variables, sampling, research ethics, experimental research, quasi-experimental research, non-experimental research, research artifacts, non-traditional research strategies, quantitative literature reviews, and legal problems in research.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PSYC 5344:

Cognitive Psychology

Survey of theoretical and empirical issues in cognitive psychology, including information processing models, attention, memory, problem solving, knowledge, reasoning, neurocognition and intelligence.

Historical and current approaches will be considered.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PSYC 5374:

Health Psychology

Theoretical and methodological contributions of the behavioral sciences to problems in the health sciences. Topics include psychosocial factors contributing to health and disease, health promotion, and psychological approaches to the prevention and treatment of physical disabilities.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PSYC 5404:

Biological Bases of Behavior

History, methods, and special topics relevant to the biological foundations of behavior. Emphasis placed on anatomy, physiology, and pharmacology of nervous system and behavioral correlates including perception, learning memory, motivation, and language.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PSYC 5544:

Cognitive Development

Cognitive development throughout the life-span. Emphasis on Piagets theory of cognitive development, information-processing approaches, perceptual development, memory development, language development, and alternatives to Piagetian theory. Coverage of the development of social-cognition, particularly communication.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): PSYC 5534

Corequisite(s):

PSYC 5554:

Social Development

Development of social competence and interactive style during infancy and childhood. Both prenatal and postnatal determinants of normal social behavior, aggression, sex role development, and nonoptimal child-environment interactions.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): PSYC 5534

Corequisite(s):

PSYC 5965:

Clinical Practicum

Supervised training appropriate to the students level of coursework and experience in interviewing, assessment, intervention techniques, community consultation, and applied research in a variety of on and off-campus settings. Maximum of 3 credit hours per course. Approximately 16 hours per week will be the normal training assignment for 3 hours credit; approximately 11 hours per week for 2 hours credit; and approximately 6 hours per week for 1 hour credit.

Credit Hour(s): 1 TO 3

Lecture Hour(s): 1 TO 16

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PSYC 5966:**Clinical Practicum**

Supervised training appropriate to the students level of coursework and experience in interviewing, assessment, intervention techniques, community consultation, and applied research in a variety of on and off-campus settings. Maximum of 3 credit hours per course. Approximately 16 hours per week will be the normal training assignment for 3 hours credit; approximately 11 hours per week for 2 hours credit; and approximately 6 hours per week for 1 hour credit.

Credit Hour(s): 1 TO 3

Lecture Hour(s): 1 TO 16

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PSYC 5974:**Independent Study**

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Independent Study

Instruction Type(s): Independent Study

Prerequisite(s):

Corequisite(s):

PSYC 5984:**Special Study**

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PSYC 5994:**Research and Thesis**

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research

Instruction Type(s): Research

Prerequisite(s):

Corequisite(s):

PSYC 6014:**Quantitative Topics in Industrial and Organizational Psychology**

Seminar provides in-depth consideration of one or more current or emergent quantitative topics relevant to the field of Industrial and Organizational Psychology. Example topics include multi-level theories and analytical techniques, meta-analysis, and generalizability theory. May be repeated with different content for a maximum of 6 hours.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): PSYC 5315, (STAT 5605, STAT 5606) OR (STAT 5615, STAT 5616) OR (STAT 5665, STAT 5666)

Corequisite(s):

PSYC 6254:**Advanced Topics in Clinical Psychology**

Seminar covering specialized topics in clinical psychology. The course will be concerned with such topics as clinical neuropsychology, pediatric psychology, the psychology of aging, biochemical theories of schizophrenia, and professional and ethical issues. May be repeated to a maximum of 9 hours.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PSYC 6264:**Child Psychopathology**

An examination of theoretical issues and current research in the assessment, treatment, and prevention of child behavior disorders. Special emphasis will be placed upon developmental factors and system-wide variables as they impact on the growing child.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): PSYC 5284

Corequisite(s):

PSYC 6924:**Advanced Topics in Industrial Psychology**

Seminar that provides in-depth coverage of theoretical perspectives, research findings, and research strategies used in the study of Industrial Psychology. Topics covered will focus on current research in the areas

content for a maximum of 6 hours.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): PSYC 5114 OR PSYC 5115, (STAT 5605, STAT 5606)

OR (STAT 5615, STAT 5616) OR (STAT 5665, STAT 5666)

Corequisite(s):

PSYC 6934:

Advanced Topics in Organizational Psychology

Seminar that provides in-depth coverage of theoretical perspectives, research findings, and research strategies used in the study of Organizational Psychology. Topics covered will focus on current research in the areas of micro and macro organizational psychology.

May be repeated with different content for a maximum of 6 hours.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): PSYC 5124 OR PSYC 5125 OR PSYC 5126, (STAT 5605, STAT 5606) OR (STAT 5615, STAT 5616) OR (STAT 5665, STAT 5666)

Corequisite(s):

PSYC 6944:

Advanced Topics in Developmental Psychology

Seminar covering specialized topics in developmental psychology. The course will be concerned with such topics as the life-span perspective, early identification of at-risk newborns, preventive interventions, and new conceptual foundations. May be repeated to a maximum of 9 hours.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PSYC 6954:

Advanced Topics in Psychological Sciences

Seminar covering advanced, specialized biobehavioral topics in Psychological Sciences. The course will be concerned with such topics as biobehavior, psychophysiology, cognitive neuroscience, sensation and perception, learning and cognitive psychology. May be repeated to a maximum of 12 hours.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PSYC 6965:

Clinical Practicum

Supervised training appropriate to the students level of coursework and experience in interviewing, assessment, intervention techniques, community consultation, and applied research in a variety of on- and off-campus settings. Maximum of 3 credit hours per course. Approximately 16 hours per week will be the normal training assignment for 3 hours credit; approximately 11 hours per week for 2 hours credit; and approximately 6 hours per week for 1 hour credit.

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PSYC 6966:

Clinical Practicum

Supervised training appropriate to the students level of coursework and experience in interviewing, assessment, intervention techniques, community consultation, and applied research in a variety of on- and off-campus settings. Maximum of 3 credit hours per course. Approximately 16 hours per week will be the normal training assignment for 3 hours credit; approximately 11 hours per week for 2 hours credit; and approximately 6 hours per week for 1 hour credit.

Credit Hour(s): 1 TO 6

Lecture Hour(s): 1 TO 6

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PSYC 6984:

Special Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PSYC 7964:

Clinical Internship

During the third, fourth, fifth, or sixth year the clinical student shall be involved in a full-time supervised internship program in a clinical setting approved by his/her advisory committee and the director of clinical psychology training program. The minimum duration shall be 11 months. Course may be repeated a maximum of four times for a maximum of 48 hours.

Credit Hour(s): 1 TO 12

Lecture Hour(s): 1 TO 12

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PSYC 7994:

Research and Dissertation

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Research

Instruction Type(s): Research

Prerequisite(s):

Corequisite(s):

STATISTICS

David Higdon, Head

Professors: Ronald Fricker; Robert Gramacy; Feng Guo; David Higdon; Ina

Hoeschele; John Morgan; Sally Morton; Eric Smith; Gordon Vining;

Associate Professors: Xinwei Deng; Pang Du; Marco Ferreira; Yili Hong; Leanna

House; Inyoung Kim; Scott Leman; George Terrell; Xiaowei Wu; Hongxiao Zhu;

Assistant Professors: Christopher Franck; Leah Johnson; Shyam Ranganathan;

Srijan Sengupta;

Collegiate Associate Professors: Anne Driscoll;

Research Assistant Professors: Allison Tegge;

Associate Professor of Practice: Jennifer Van Mullekom;

Professor of Practice: Alexandra Hanlon; Thomas Woteki;

Research Associate Professors: Laura Freeman;

Graduate Contact: chconne1@vt.edu

Director of Graduate Programs: leman@vt.edu

Graduate Site:

https://www.stat.vt.edu/content/stat_vt_edu/en/academics/graduate.html

Student Handbook: <https://www.stat.vt.edu/Academics/graduate/graduate->

[handbook.html](#)

Founded in 1949, the Department of Statistics at Virginia Tech is the third oldest in the nation. Our program specializes in training students in statistical theory balanced with extensive applications including practical experience via the Statistical Applications and Innovations Group (SAIG). Over 875 master's degrees and 368 doctoral degrees have been awarded by the department. The 18-month master's program is a model of the time-efficient education of statisticians. The doctoral program includes specialized tracks in traditional and industrial statistics, bioinformatics, computational statistics (data analytics), and environmetrics.

SPECIAL FACILITIES

Through the Statistical Applications and Innovations Group (SAIG), students in cooperation with faculty members become involved in on-campus collaboration activities. M.S. students are required to participate in statistical collaboration within SAIG for at least one semester and Ph.D. students for at least three semesters. The department has several laboratories housing state-of-the-art Linux and PC networks. Students have access to these for collaboration, course work, and research. Students gain extensive experience with modern statistical software for experimental design, data management and analysis, and computer programming for statistical purposes.

DEGREES OFFERED

MS Degree

Offered In (Blacksburg)

TOEFL

Paper: (550.0)

Computer: (213.0)

iBT: (90.0)

GRE

General Test: Verbal (150.0), Quantitative (160.0), Analytical (3.0)

The M.S. plan of study requires 34 semester hours of work, of which 32 semester hours must be taken within the department. Additional courses rounding out a plan of study may be taken at the graduate level in applied or theoretical statistics, mathematics, or in approved areas of application. Each student must pass a qualifying examination after completing the core courses and a final oral examination after completing the plan of study.

PhD Degree

Offered In (Blacksburg)

TOEFL

Paper: (550.0)

Computer: (213.0)

iBT: (90.0)

GRE

General Test: Verbal (150.0), Quantitative (160.0), Analytical (3.0)

The Ph.D. plan of study requires a minimum of 90 semester hours of work beyond the baccalaureate, including at least 48 semester hours of

coursework and at least 30 semester hours of research toward the dissertation. In addition to the core courses for the M.S. (or equivalent courses if a student enters the program with advanced standing from another university), the candidate for the Ph.D. must take four Ph.D. level courses including at least one of Measure and Probability (STAT 6105) or Advanced Topics in Statistical Inference (STAT 6114). Each candidate for the Ph.D. must pass the qualifying examination at the Ph.D. level. Flexibility is provided to the graduate program through the following Ph.D. areas of concentration: General Statistical Methodology and Theory; Biostatistics/Bioinformatics; Computational Statistics; Environmental Statistics; Business, Government and Industrial (BIG) Statistics, and even Sports Analytics. The General Statistical Methodology and Theory area of concentration encompasses the general pursuit of research in statistical theory and methods, allowing considerable freedom in choice of coursework within and outside the department. The Biostatistics/Bioinformatics, Computational, Environmental, BIG, and Sports Analytics areas of concentration offer more specialized statistical training geared toward application areas in which the department has particular expertise. These latter areas of concentration require more specialized coursework and research focus to be decided by the student and her/his advisory committee.

GRADUATE COURSES (STAT)

STAT 5014:

Introduction to Statistical Program Packages

Introduction to computing facilities (mainframe and microcomputers), conversational monitoring system (CMS), and statistical program computer packages. Restricted to Statistics majors.

Credit Hour(s): 1

Lecture Hour(s): 1

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s): null null

STAT 5024:

Effective Communication in Statistical Consulting

Communication skills necessary to be effective interdisciplinary statistical collaborators. Explaining and presenting statistical concepts to a non-statistical audience, helping scientists answer their research questions, and managing an effective statistical collaboration meeting.

Co: 5204 or 5616.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): (STAT 5034, STAT 5044) OR STAT 5615

Corequisite(s): null null

STAT 5034:

Inference Fundamentals with Applications to Categorical Data

Fundamental concepts in statistical inference and related methods: point estimation, interval estimation, hypothesis testing, permutation, and resampling-based methods. Emphasizes use of R programming package, visualizing data, computation and interpretation of effect sizes, statistical simulation to compare the performance of available methods, role of sample size in statistical analysis, contingency tables, and use of model contrasts to assess specific hypotheses in the context of larger models.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s): STAT 5014, STAT 5044

STAT 5044:

Regression and Analysis of Variance

Principles and methods of data analysis employing linear models for continuous response variables. Topics include both classical descriptive measures and modern computer-based techniques for data visualization; simple, multiple and weighted regression; analysis of variance for one-way and higher-way classifications; fixed, mixed, and random effects models; analysis of covariance; detection and correction of modeling flaws; statistical power.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): STAT 5615, STAT 4584 OR MATH 4584

Corequisite(s): STAT 5014

STAT 5054:

Introduction to Statistical Computing

Introduction to modern programming packages for data analysis. Basics of coding, language syntax, and statistical functionality to read in raw data files and data sets, subset data, create variables, and recode data. Summaries in the form of tables and graphs. Data analysis using standard statistical methods and data management and analysis of large data sets. Parallel computing. Applied data analysis is emphasized rather than statistical theory. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

STAT 5104:**Probability and Distribution Theory**

Fundamental concepts of probability, random variables and their distributions, functions of random variables, mathematical expectations, and stochastic convergence.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): MATH 4526

Corequisite(s):

STAT 5105G:**Advanced Theoretical Statistics**

5105G: Probability theory, counting techniques, conditional probability; random variables, moments; moment generating functions; multivariate distributions; transformations of random variables; order statistics.

5106G: Convergence of sequences of random variables; central limit theorem; methods of estimation; hypothesis testing; linear models; analysis of variance. Pre: 5105G: Graduate Standing; 5106G: 5105G.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

STAT 5106G:**Advanced Theoretical Statistics**

5105G: Probability theory, counting techniques, conditional probability; random variables, moments; moment generating functions; multivariate distributions; transformations of random variables; order statistics.

5106G: Convergence of sequences of random variables; central limit theorem; methods of estimation; hypothesis testing; linear models; analysis of variance. Pre: 5105G: Graduate Standing; 5106G: 5105G.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): STAT 5105G

Corequisite(s):

STAT 5114:**Statistical Inference**

Decision theoretic formulation of statistical inference, concept and methods of point and confidence set estimation, notion and theory of

hypothesis testing, relation between confidence set estimation and hypothesis testing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s): STAT 5104

STAT 5124:**Linear Models Theory**

A study of the theory underlying the general linear model and general linear hypothesis. Applications in linear regression (full rank) and analysis of variance.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): STAT 5114, MATH 5524

Corequisite(s):

STAT 5134:**Tools and Approaches for Policy-Making in STEM-H Domains**

Techniques for translating theory-driven, qualitative concepts into quantitative data-focused modeling to address policy problems. Quantitative and computational tools including statistical inference and hypothesis testing, system dynamics, and economic analysis. Modeling paradigms and common challenges in modeling. Modern data analytic practices, including good collection, storage and visualization techniques. Problem definitions and application to real-world policy-related problems and implementation in modern software packages. Understanding complexity. Critical evaluation of challenges and common pitfalls in quantitative modeling. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

STAT 5204:**Experimental Design and Analysis I**

Principles and concepts of experimental design; systematic overview and discussion of basic designs from the point of view of blocking, error reduction, and treatment structure; and development of analysis based on linear models.

134 Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): STAT 5104 OR STAT 5616

Corequisite(s):

STAT 5204G:

Experimental Design: Concepts and Applications

Fundamental principles of designing and analyzing experiments with application to problems in various subject matter areas. Completely randomized, randomized complete block and Latin square designs, analysis of covariance, split-plot designs, factorial and fractional factorial designs, incomplete block designs, repeated measures, power and sample size, mean separation procedures.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): STAT 5605 OR STAT 5615

Corequisite(s):

STAT 5214G:

Advanced Methods of Regression Analysis

Multiple regression including variable selection procedures; detection and effects of multicollinearity; identification and effects of influential observations; residual analysis; use of transformations. Non-linear regression, the use of indicator variables, and logistic regression. Use of SAS.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): STAT 5605 OR STAT 5615

Corequisite(s):

STAT 5304:

Statistical Computing

Computational methods for statistical computing problems. Orthogonal transformations, sweep operators, and other numerical methods applied to general optimization techniques for maximum likelihood and least squares estimation problems. Knowledge of SAS programming language required. Even years.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): STAT 5124

Corequisite(s):

STAT 5314:

Monte Carlo Methods in Stats

Theoretical and applied aspects of simulation-based sampling methodology. Monte Carlo integration, importance sampling, Markov chain Monte Carlo, particle methods, Kalman filtering. Programming in Matlab, R, or SAS.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): STAT 5114

Corequisite(s):

STAT 5364:

Hierarchical Modeling

Hierarchical modeling techniques as applied to assess data with atypical features, such as non-normal responses (e.g., binary, discrete survival, continuous mixtures), censored/missing observations, multivariate responses, repeated measures, and nested structures. Classical and Bayesian techniques for assessing models. Programming experience in R, S+, or Matlab required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): STAT 5044, STAT 5104, STAT 5444

Corequisite(s):

STAT 5364G:

Advanced Statistical Genomics

Statistical methods for bioinformatics and genetic studies, with an emphasis on statistical analysis, assumptions and problem-solving. Topics include: basic concepts of genes and genomes, commonly used statistical methods for gene identification, association mapping and other related problems. Focus on statistical tools for gene expression studies and association studies, multiple comparison procedures, likelihood inference and preparation for advanced study in the areas of bioinformatics and statistical genetics.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): STAT 5616

Corequisite(s):

STAT 5374:**Statistical Epidemiology and Observation Studies**

Statistical methodology for epidemiology and observational studies. Statistical evaluation and inference for risk and prevalence of population safety and disease risk factors. Epidemiology and observational study design. Emphasis on casual inference and statistical models. Pre: 5034 or 5124 or 5615.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): STAT 5034 OR STAT 5124 OR STAT 5615

Corequisite(s):

STAT 5414:**Time Series Analysis I**

Analysis of data when observations are not mutually independent, stationary and nonstationary time series, linear filtering, trend elimination, prediction, and applications in economics and engineering.

Even years.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): STAT 5114

Corequisite(s):

STAT 5434:**Applied Stochastic Processes**

Stochastic processes in statistical applications including Markov chains, Poisson processes, renewal processes, branching processes, random walks, martingales, Brownian motion and related stationary Gaussian processes.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): STAT 5104

Corequisite(s):

STAT 5444:**Bayesian Statistics**

Introductory course of Bayesian statistics on basic concepts of probability, Bayesian inference of Normal, Binomial, Poisson, Uniform and other common distributions, selections of prior information, Bayesian decision theory, Bayesian analysis of regression and analysis of variance and Bayesian foundation. Even years.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): STAT 5114

Corequisite(s):

STAT 5444G:**Advanced Applied Bayesian Statistics**

Bayesian methodology with emphasis on applied statistical problems: data displaying, prior distribution elicitation, posterior analysis, models for proportions, means and regression. Pre: Graduate Standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

STAT 5454:**Reliability Theory**

Basic concepts of lifetime distributions, types of censoring, inference procedures for exponential, Weibull and extreme value distributions, nonparametric estimation of survival function, kernel density estimation, accelerated life testing, and goodness of fit tests.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): STAT 4106

Corequisite(s):

STAT 5474 (ISE 5474):**Statistical Theory of Quality Control**

Development of statistical concepts and theory underlying procedures used in quality control applications. Sampling inspection procedures, the sequential probability ratio test, continuous sampling procedures, process control procedures, and experimental design.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): STAT 5104, STAT 5114

Corequisite(s):

STAT 5484 (AAEC 5484):

Forecasting economic, agricultural and environmental data using basic linear and non-linear time series models. Emphasis on programming and computational implementation of time series model-selection techniques and practical applications. Pre: Graduate Standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

STAT 5504:

Multivariate Statistical Methods

Methods of inference for multivariate distributions. Multivariate distributions, location and dispersion problems for one and two samples, multivariate analysis of variance, linear models, repeated measurements, inference for dispersion and association parameters, principal components, discriminant and cluster analysis, and simultaneous inference. R will be used.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): (STAT 5104 OR STAT 5616)

Corequisite(s):

STAT 5504G:

Advanced Applied Multivariate Analysis

Non-mathematical study of multivariate analysis. Multivariate analogs of univariate test and estimation procedures. Simultaneous inference procedures. Multivariate analysis of variance, repeated measures, inference for dispersion and association parameters, principle components analysis, discriminant analysis, cluster analysis.

Prerequisite: Graduate Standing required

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): STAT 5616 OR STAT 5606

Corequisite(s):

STAT 5514:

Regression Analysis

Classical and modern techniques in regression analysis. Use of modern regression techniques to diagnose collinearity, leverage, and outliers.

Model discrimination using cross validation techniques. The study of transformations, biased estimation, and nonlinear regression.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): STAT 5124 OR STAT 5616

Corequisite(s):

STAT 5514G:

Advanced Contingency Table Analysis

Statistical techniques for frequency data. Goodness-of-fit. Tests and measures of association for two-way tables. Log-linear models for multidimensional tables. Parameter estimation, model selection, incomplete tables, ordinal categories, logistic regression. Use of SAS or SPSS statistical software.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): STAT 4706 OR STAT 5616

Corequisite(s):

STAT 5525 (CS 5525):

Data Analytics

5525: Basic techniques in data analytics including the preparation and manipulation of data for analysis and the creation of data files from multiple and dissimilar sources. The data mining and knowledge discovery process. Overview of data mining algorithms in classification, clustering, association analysis, probabilistic modeling, and matrix decompositions. Detailed study of classification methods including tree-based methods, Bayesian methods, logistic regression, ensemble, bagging and boosting methods, neural network methods, use of support vectors and Bayesian networks. Detailed study of clustering methods including k-means, hierarchical and self-organizing map methods. Prerequisite: Graduate Standing required. 5526: Techniques in unsupervised and visualized learning in high dimension spaces. Theoretical, probabilistic, and applied aspects of data analytics. Methods include generalized linear models in high dimensional spaces, regularization, lasso and related methods, principal component regression (pca), tree methods, and random forests. Clustering methods including k-means, hierarchical clustering, biclustering, and model-based clustering will be thoroughly examined. Distance-based learning methods include multi dimensional scaling, the self organizing map, graphical/network models, and isomap. Supervised learning will consist of discriminant analyses, supervised pca, support vector machines, and kernel methods.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

STAT 5526 (CS 5526):

Data Analytics

5525: Basic techniques in data analytics including the preparation and manipulation of data for analysis and the creation of data files from multiple and dissimilar sources. The data mining and knowledge discovery process. Overview of data mining algorithms in classification, clustering, association analysis, probabilistic modeling, and matrix decompositions. Detailed study of classification methods including tree-based methods, Bayesian methods, logistic regression, ensemble, bagging and boosting methods, neural network methods, use of support vectors and Bayesian networks. Detailed study of clustering methods including k-means, hierarchical and self-organizing map methods.

Prerequisite: Graduate Standing required. 5526: Techniques in unsupervised and visualized learning in high dimension spaces. Theoretical, probabilistic, and applied aspects of data analytics. Methods include generalized linear models in high dimensional spaces, regularization, lasso and related methods, principal component regression (pca), tree methods, and random forests. Clustering methods including k-means, hierarchical clustering, biclustering, and model-based clustering will be thoroughly examined. Distance-based learning methods include multi dimensional scaling, the self organizing map, graphical/network models, and isomap. Supervised learning will consist of discriminant analyses, supervised pca, support vector machines, and kernel methods.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): STAT 5525 OR CS 5525

Corequisite(s):

STAT 5544:

Spatial Statistics

Spatial data structures: geostatistical data, lattices and point patterns. Stationary and isotropic random fields. Autocorrelated data structures. Semivariogram estimation and spatial prediction for geostatistical data. Mapped and sampled point patterns. Regular, completely random and clustered point processes. Spatial regression and neighborhood analyses for data on lattices.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): STAT 5124

Corequisite(s):

STAT 5554:

Functional Data Analysis

Functional summary statistics, phase-plane plots, functional principal component analysis, functional regression models, principal differential analysis, dynamic models, analysis of manifold data, topological data analysis, data analysis of complex objects.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): STAT 5124, STAT 5114, STAT 5044

Corequisite(s):

STAT 5574:

Response Surface Design and Analysis I

Use of response surface analysis to design and analyze industrial experiments. First and second order models. First and second order experimental designs. Use of model diagnostics for finding optimum operating conditions. Even years.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): STAT 5204

Corequisite(s):

STAT 5594:

Topics in Biostatistics

Course with variable content; specialized application of statistical theory and methodology to biological and medical sciences; topics include bioassay, epidemiology, survival analysis, and statistical ecology. May be repeated for credit with different topics. Odd years.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): STAT 5114

Corequisite(s):

STAT 5605:

Biometry

5605: The normal distribution, estimation, hypothesis testing, simple linear regression, and one-way analysis of variance with applications to

the biological sciences. 5606: Experimental design, nested and factorial analysis of variance, linear regression and correlation, and the use of SAS, with applications to the biological sciences.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

STAT 5606:

Biometry

5605: The normal distribution, estimation, hypothesis testing, simple linear regression, and one-way analysis of variance with applications to the biological sciences. 5606: Experimental design, nested and factorial analysis of variance, linear regression and correlation, and the use of SAS, with applications to the biological sciences. Knowledge of CMS required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

STAT 5615:

Statistics in Research

5615: Concepts in statistical inference, including basic probability, estimation, and test of hypothesis, point and interval estimation and inferences; categorical data analysis; simple linear regression; and one-way analysis of variance. 5616: Multiple linear regression; multi-way classification analysis of variance; randomized block designs; nested designs; and analysis of covariance. One year of Calculus. CMS.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

STAT 5616:

Statistics in Research

5615: Concepts in statistical inference, including basic probability, estimation, and test of hypothesis, point and interval estimation and inferences; categorical data analysis; simple linear regression; and one-way analysis of variance. 5616: Multiple linear regression; multi-way classification analysis of variance; randomized block designs; nested

designs; and analysis of covariance. One year of Calculus and knowledge of CMS required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

STAT 5664:

Applied Statistical Time Series Analysis for Research Scientists

Applied course in time series analysis methods. Topics include regression analysis, detecting and addressing autocorrelation, modeling seasonal or cyclical trends, creating stationary time series, smoothing techniques, forecasting errors, and fitting autoregressive integrated moving average models.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): STAT 5616 OR STAT 5606

Corequisite(s):

STAT 5674:

Methods in Biostatistics

Statistical principles and methods required for effective clinical trial and clinical experiment design and analysis. Topics include graphical and numerical exploratory data analysis, and comparative tests of categorical, ordinal, and continuous data, simple, multiple linear and logistic regression analysis, design of experiments and sampling theory. Additional topics include diagnostic tests, relative risk, odd ratio, and estimation of effective dose. Students will learn to properly interpret output from statistical software. Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

STAT 5684:

Survival Analysis

Models and methods for time-to-event data with focus on biological and biomedical applications. Topics includes types of censoring and truncation; likelihood construction; survival function estimation; nonparametric two or more samples tests; Cox semiparametric regression, time-dependent covariates; regression diagnostics;

competing risks; frailty model. Pre-requisite: Working knowledge of statistical software.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): STAT 5044, STAT 5104, STAT 5114

Corequisite(s):

STAT 5694:

Longitudinal Data Analysis

Application and theory for longitudinal data analysis for both continuous and categorical response data, including the use of statistical software for data analysis. Topics include ANOVA, MANOVA, random-effects model, covariance pattern models, generalized estimation equations models, random-effects logistic regression models, and missing data in longitudinal studies. Pre-requisite: Working knowledge of statistical software.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): STAT 5004, STAT 5104, STAT 5114

Corequisite(s):

STAT 5754:

Internship in Statistics

Full time, supervised internship experience at a company or government agency performing statistical analysis. May be repeated for a maximum of 3 hours toward an M.S. degree and 6 hours toward a Ph.D. degree. Graduate standing in statistics and permission of department required.

Credit Hour(s): 1 TO 6

Lecture Hour(s): 1 TO 6

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): STAT 5024

Corequisite(s):

STAT 5894:

Final Examination

NONE

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

STAT 5904:

Project and Report

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research, Online Research

Instruction Type(s): Research, Online Research

Prerequisite(s):

Corequisite(s):

STAT 5924:

Graduate Seminar

Special topics in statistical theory and applications. May be taken for credit two times (max. 2C).

Credit Hour(s): 1

Lecture Hour(s): 1

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

STAT 5974:

Independent Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Independent Study, VI

Instruction Type(s): Independent Study, VI

Prerequisite(s):

Corequisite(s):

STAT 5984:

Special Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

STAT 5994:

Research and Thesis

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research, Online Research

Instruction Type(s): Research, Online Research

Prerequisite(s):

Corequisite(s):

STAT 6105:

Measure and Probability

Development of measure theoretic foundations of probability theory.

6105: sigma fields, probability, and general measures; random variables, measurability and distributions, integration, and expectation; product measures; Radon-Nikodym theorem and conditioning. 6106: Random variables and strong and weak laws of large numbers; characteristic functions, central limit theorem and martingales; stochastic processes and Brownian motion. 6105 partially duplicates Math 5225. Must be enrolled in PhD program.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): STAT 5104 OR MATH 4525

Corequisite(s):

STAT 6114:

Advanced Topics in Statistical Inference

Advanced course in the theory of inference for graduate students in statistics and other qualified graduate students. Develops foundations, sufficiency, information, estimation, hypothesis testing, invariance, and unbiasedness.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): STAT 5114

Corequisite(s):

STAT 6424:

Multivariate Statistical Analysis

Foundations of multivariate analysis. Distribution theory of vectors and matrices, inequalities, limit theory, the structure of some multivariate location-scale parameter families, derived distributions, invariant distributions, the principle of invariance in estimation and testing for multivariate location and scale parameters, and robust aspects of normal-theory multivariate procedures.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): STAT 5504

Corequisite(s):

STAT 6474:

Adv Topics Bayesian Statistics

Advanced concepts and methods in Bayesian analysis, including specifying priors, large sample theory, adaptive rejection sampling, adaptive rejection metropolis Hastings sampling, reverse jump Markov Chain Monte Carlo, model selection, nonparametric and semiparametric Bayesian methods using nonparametric priors, and Bayesian survival models.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): STAT 5114, STAT 5514, STAT 5444

Corequisite(s):

STAT 6494:

Advanced Topics in Mathematical Statistics

Advanced treatment beyond standard course offerings in topics such as theory of inference, nonparametrics, sequential analysis, and limit theory. May be repeated for credit with different topics.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): STAT 5114

Corequisite(s):

STAT 6504:

Experimental Design and Analysis II

Theoretical treatment of construction and analysis of various types of incomplete block and factorial designs.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): STAT 5124, STAT 5204

Corequisite(s):

STAT 6514:

Advanced Topics in Regression

Advanced notions in modern regression techniques and diagnostics. The underlying theory and concepts associated with estimation methods for handling collinearity. Theory behind modern criteria for selection of candidate models. The development of single and multiple outlier and

influence diagnostics. Odd years.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): STAT 5124, STAT 5514

Corequisite(s):

STAT 6544:

Surrogate Modeling

Statistical techniques at the interface between mathematical modeling via computer simulation, computer model meta-modeling (i.e., emulation/surrogate modeling), calibration to field data, and geometric and model-based sequential design, and Bayesian optimization.

Historical literature, canonical examples, and modern nonparametric methods like Gaussian processes. Computation and implementation, fidelity enhancements and approximate methods for big data. Real-world field experiments and computer model simulations from the physical and engineering sciences.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): STAT 5044, STAT 5204, STAT 5304, STAT 5444

Corequisite(s):

STAT 6564 (ECON 6564) (AAEC 6564):

Bayesian Econometric Analysis

Bayesian estimation of economic models, with focus on Gibbs sampling, hierarchical modeling, data augmentation, and model search. Strong emphasis on programming and computational implementation.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

STAT 6574:

Response Surface Design and Analysis II

Advanced techniques and theory in response surface analysis and design. Robustness of designs. Thorough study of the notion of rotatability. Optimal design criteria and designs for estimating slopes of response surfaces. Mixture designs. Study of model misspecification.

Even years.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): STAT 5574

Corequisite(s):

STAT 6634 (EDRE 6634):

Advanced Statistics for Education

Multiple regression procedures for analyzing data as applied in educational settings, including curvilinear regressions, dummy variables, multicollinearity, and introduction to path analysis.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): STAT 5634

Corequisite(s):

STAT 6984:

Special Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

STAT 7994:

Research and Dissertation

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research, Online Research

Instruction Type(s): Research, Online Research

Prerequisite(s):

Corequisite(s):

FISHERIES AND WILDLIFE SCIENCES

Joel Snodgrass, Head

Emeriti Faculty: Steve McMullin; Brian Murphy; Richard Neves;

Professors: Kathleen Alexander; Paul Angermeier; C Dolloff; James Fraser; Emmanuel Frimpong; Carola Haas; Eric Hallerman; William Hopkins; Yan Jiao; Sarah Karpanty; Marcella Kelly; Donald Orth; Dean Stauffer;

Associate Professors: Leandro Castello; William Ford; James Parkhurst;

Assistant Professors: Ashley Dayer; Luis Escobar Quinonez; Francesco Ferretti;
Holly Kindsvater;

Graduate Contact: frimp@vt.edu

Graduate Site: https://fishwild.vt.edu/Graduate/prospective_students.html

The Department of Fish and Wildlife Conservation offers one of the leading programs of its type. The comprehensive curriculum covers fisheries and wildlife biology and ecology, habitat analysis, and human dimensions of natural resource science and management. Faculty specialties include endangered species management, cold water stream management, marine fisheries and conservation, conservation genetics, tropic ecology, recycling aquaculture systems, wildlife physiology and ecotoxicology, human-wildlife interactions (including disease transmission), habitat analysis and management, geographic information systems, human dimensions, policy and administration. M.S. programs stress preparation for professional careers in public agencies and private organizations with fisheries and wildlife responsibilities. Doctoral programs stress preparation for research and leadership positions in public agencies and for university faculty positions.

SPECIAL FACILITIES

The department maintains facilities in Cheatham and Latham Halls and the Integrated Life Sciences Building for laboratory analysis, small-scale aquatic experiments, small-animal holding, computer analysis, and geographic information systems. The latest computer technology is available. The Wild Animal Research Facilities (WARF) are located at the edge of the campus adjacent to an approximately 45 ac. woodlot that serves as a living-learning outdoor laboratory for research and teaching. The WARF consist of aquaculture laboratories that provide state-of-the-art facilities for aquaculture and endangered aquatic species propagation, the research aviary, and the black bear holding and research facilities.

Black Bear Research Facility

The Black Bear Research Facility provide housing and secondary and tertiary containment for adult and juvenile bears. The facility has associated investigator housing and laboratory space designed for physiological investigations.

Conservation Aquaculture Center

The Conservation Aquaculture Center is an approximately 5400 sq ft building designed for the culture and propagation of aquatic organisms. There are a range of tanks and other artificial aquatic habitat available from 10 gallon aquariums to artificial streams and large aquaculture tanks. The open and flexible space of this facility allows set-up of just about any aquaculture configuration or experimental design.

Integrated Life Sciences Building

Genetics and disease ecology laboratories are located in the Integrated Life Sciences Building in the Corporate Research Park at the south end of campus. The laboratories and accompanying shared facilities of ILSB provide modern genetic analyses and BSL Level 2 space.

Julian Cheatham Hall

Cheatham Hall houses the department's teaching and most of its

research laboratories, computer labs, faculty and graduate student offices, and administration. Key research spaces include laboratories focusing on applied mammal and fish ecology, human dimensions of natural resources management, wildlife ecology, fish landscape ecology, wildlife behavioral ecology, threatened and endangered species, fluvial fishes and wildlife habitat and population analysis.

Latham Hall

Dedicated in 2006, Latham Hall provides well-outfitted laboratory space, environmentally controlled chambers, a necropsy room, and a walk-in freezer. Laboratory and research spaces include: the Fish Ecology and Management Laboratory, Wildlife Ecotoxicology and Physiological Ecology Laboratory, and the Ecological Research Archive.

Mussel Propagation Center

The Mussel Propagation Center is an open, reconfigurable aquaculture facility designed specifically for the propagation of North American freshwater mussels. An adjacent pond provides a food source for young mussels and the facility is equipped to house fish that function as hosts for the mussel larvae. An adjacent grow-out facility provides the production capacity to support reintroduction and augmentation programs for endangered mussel species.

Research Aviary

Our Research Aviary is a unique facility with 16 replicated aviary rooms and is located at our Wild Animal Research Facilities. Each room can house a small flock of songbirds or can house family groups of species. Other features include partial roofing of each room with an outer, mesh-enclosed area so the birds can experience daylight cycles and natural temperature changes, but remain sheltered from extreme weather.

DEGREES OFFERED

MS Degree

Offered In (Blacksburg)

TOEFL

Paper: (550.0)

Computer: (213.0)

iBT: (80.0)

We offer M.S. and Ph.D. degrees in Fisheries and Wildlife Sciences. Students specialize in either Fisheries or Wildlife Science. Coursework is tailored to the interest and needs of the students in consultation with the student's graduate committee. Successful applicants to our program usually have grade point averages above 3.5/4.0 (over the last 60 semester hours). Discipline-related experience is always a plus. Students with backgrounds in fisheries, wildlife, or natural resource management tend to be accepted at a higher rate than students with degrees in biology or environmental sciences. Although obviously there are many similarities between the fields, having a solid ecological background, an applied perspective, and background in policy and management is very helpful as you pursue an advanced degree in fisheries and wildlife. If you do not have a B.S. in a resource

management field, and you have the opportunity to take courses in natural resource management or fisheries and wildlife management, you would increase your chances of acceptance. You also might gain a better feel for whether you would prefer enrolling in an ecology program or a fisheries and wildlife program. We accept students into the Ph.D. program only if they have completed an M.S. degree. We accept students only when a faculty member has financial resources to support stipend, tuition, and research expenses. Updated lists of available positions are posted on the department's webpage. Please check the list of available positions on a regular basis to see if there are opportunities for the upcoming semesters that match your research interests. Please be aware that we receive some funding opportunities at the last minute. It will be worth checking this web site regularly. You may want to check the list of faculty research and academic interests and correspond with a particular faculty member about likely openings in the next year or two. If you submit a formal application, you will be considered for any openings. All graduate students must conduct M.S. or Ph.D. research projects, in addition to course work chosen in consultation with an advisory committee. Research projects are designed in a student-written research working plan that is approved by the advisory committee. In almost all cases, students are funded on research contracts or teaching assistantships, both of which require substantial work outside of degree requirements. All students must deliver at least two seminars and write a semi-technical manuscript about their research. Doctoral students are required to complete a diagnostic assessment of their competencies in five areas of knowledge within the first semester in residence and must teach at least one semester, regardless of funding source. All students are expected to participate in the professional and collegial life of the department and its professional specialty by attending seminars and professional meetings, participating in student organizations, and serving on departmental and professional committees.

PhD Degree

Offered In (Blacksburg)

TOEFL

iBT: (80.0)

We offer M.S. and Ph.D. degrees in Fisheries and Wildlife Sciences. Students specialize in either Fisheries or Wildlife Science. Coursework is tailored to the interest and needs of the students in consultation with the student's graduate committee. Successful applicants to our program usually have grade point averages above 3.5/4.0 (over the last 60 semester hours). Discipline-related experience is always a plus. Students with backgrounds in fisheries, wildlife, or natural resource management tend to be accepted at a higher rate than students with degrees in biology or environmental sciences. Although obviously there are many similarities between the fields, having a solid ecological background, an applied perspective, and background in policy and management is very helpful as you pursue an advanced degree in fisheries and wildlife. If you do not have a B.S. in a resource management field, and you have the opportunity to take courses in natural resource management or fisheries and wildlife management, you would increase your chances of acceptance. You also might gain a better feel for whether you would prefer enrolling in an ecology program or a fisheries and wildlife program. We accept students into the Ph.D. program only if they have completed an M.S. degree. We accept students only when a faculty member has financial resources to support stipend, tuition, and research expenses. Updated lists of available positions are posted on the department's webpage. Please check the list of available positions on a regular basis to see if there are opportunities for the upcoming semesters that match your research interests. Please

be aware that we receive some funding opportunities at the last minute. It will be worth checking this web site regularly. You may want to check the list of faculty research and academic interests and correspond with a particular faculty member about likely openings in the next year or two. If you submit a formal application, you will be considered for any openings. All graduate students must conduct M.S. or Ph.D. research projects, in addition to course work chosen in consultation with an advisory committee. Research projects are designed in a student-written research working plan that is approved by the advisory committee. In almost all cases, students are funded on research contracts or teaching assistantships, both of which require substantial work outside of degree requirements. All students must deliver at least two seminars and write a semi-technical manuscript about their research. Doctoral students are required to complete a diagnostic assessment of their competencies in five areas of knowledge within the first semester in residence and must teach at least one semester, regardless of funding source. All students are expected to participate in the professional and collegial life of the department and its professional specialty by attending seminars and professional meetings, participating in student organizations, and serving on departmental and professional committees.

GRADUATE COURSES (FIW)

FIW 5004:

Graduate Seminar

Advanced exploration of special topics in fisheries and wildlife, through literature reviews, guest speakers, student/faculty presentations, and small group projects. Topics and format vary depending on interests of faculty and graduate students. May be repeated.

Credit Hour(s): 1

Lecture Hour(s): 1

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

FIW 5114:

Fisheries and Wildlife Conservation Genetics

Population genetics of terrestrial and aquatic animals as applied to fisheries and wildlife management, endangered species management, and ecosystem protection. Discussion of genetic variability and analytic techniques, population genetic processes, and practical applications.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

FIW 5254:

Design&Analysis Field Study

Philosophy and principles of field study design and hypothesis testing. Habitat and population sampling design and analysis for terrestrial and aquatic systems. Integrating population and habitat data to develop resource selection functions. Principles of habitat modeling and community measures. Discussion and comparison of current trends in data analysis.

Credit Hour(s): 3

Lecture Hour(s): 2

Instruction Type(s): Lab, Lecture, VB, Online Lecture

Instruction Type(s): Lab, Lecture, VB, Online Lecture

Prerequisite(s): STAT 5605 OR STAT 5615 OR STAT 5674

Corequisite(s):

FIW 5314:

Vertebrate Population Ecology and Management

Wild animal population and evolutionary ecology. Historical and current research concerning theories of population growth, population regulation, spatially structured populations, evolution of life histories, and the scaling up of population concepts to community and ecosystem applications. Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

FIW 5414:

Endangered Species Management

History, philosophy, and practice of endangered species management with emphasis on management in the United States. Biology of extinction, rationale for preservation, endangered species legislation, status surveys, management goals, habitat protection, recovery plans.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): FIW 4414 OR FIW 4614 OR BIOL 4404

Corequisite(s):

FIW 5464G:

Advanced Human Dimensions of Fisheries and Wildlife

Values, attitudes and opinions of people towards fish and wildlife. Social, economic, legal and political aspects of fisheries and wildlife management. Roles of professionals and the public in fish and wildlife policy processes. Contemporary fish and wildlife policy issues. Graduate Standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

FIW 5514:

Fish Population Dynamics and Modeling

Theory and application of fish population models for managing recreational and commercial fisheries. Estimation of basic fish population statistics (abundance, mortality, growth). Development and application of models for age-structured populations, bioenergetics, growth, stock-recruitment, yield, predation, and competition.

Credit Hour(s): 0 OR 4

Lecture Hour(s): 0 OR 3

Instruction Type(s): Lab, Lecture, Online Lecture

Instruction Type(s): Lab, Lecture, Online Lecture

Prerequisite(s): FIW 4714

Corequisite(s):

FIW 5534G:

Advanced Wetland Ecology and Management

Introduction to the variety of wetland systems found in North American, with emphasis on eastern and mid-Atlantic wetland systems. Origin and processes of formation of wetlands, functions and values of wetlands, wetland delineation, wetland classification, regulatory processes affecting wetlands. Objective of management and techniques used to protect and/or manipulate wetland systems for wildlife and other human needs. Graduate Standing required.

Credit Hour(s): 0 TO 3

Lecture Hour(s): 0 OR 2

Instruction Type(s): Lab, Lecture, Online Lecture

Instruction Type(s): Lab, Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

FIW 5624G:

Advanced Marine Ecology

Marine organisms; biological, ecological, chemical and physical processes of marine ecosystems in open-sea, coastal, and benthic environments; research methods and models in marine ecosystem stimulation; fisheries in a dynamic ecosystem; human interference and conservation. Graduate Standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

FIW 5714G:

Advanced Fisheries Management

History, theory, and practice of fisheries management. Emphasis on basic strategies used in effective management objectives. Synthesis of fish population dynamics and manipulation, habitat improvement, and human management to achieve objectives. Case studies of major fisheries. Pre-requisite: Graduate Standing required.

Credit Hour(s): 4

Lecture Hour(s): 3

Instruction Type(s): Lab, Lecture, Online Lecture

Instruction Type(s): Lab, Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

FIW 5764:

Systems Ecology and Conservation

Holistic approaches to understanding sustainable management and conservation of natural environments. Review of the Systems Ecology and Social-Ecological Systems school of thought. Focus on the use of energy principles and the resilience concept to articulate natural resource problems as integrated systems. Application of energy principles and resilience concept to real world examples. Discussion-based class. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

FIW 5774:

Spatial Modeling of Species and Niches

Theory and practice of species distribution modeling, emphasizing statistical and ecological niche theory underpinnings; probability and matrix algebra for data manipulation and inference; scale, hierarchy, and network concepts for aquatic and terrestrial habitats; spatial dependence and autocorrelation in species and habitat data; sources and limitations of data for modeling species distributions; foundations, choice, and implementation of statistical models in appropriate software, emphasizing machine learning techniques; model assumptions, uncertainty, and model evaluation; model-based inference and null hypothesis testing in species distribution modeling; interpretation and conservation and management applications of models for binary data.

Credit Hour(s): 0 OR 3

Lecture Hour(s): 0 OR 2

Instruction Type(s): Lab, Lecture, VB, Online Lecture

Instruction Type(s): Lab, Lecture, VB, Online Lecture

Prerequisite(s): STAT 5605 OR STAT 5615

Corequisite(s):

FIW 5814:

Stream Habitat Management

Application of stream ecology, fish biology, hydrology, and hydraulics to the protection, restoration, and enhancement of stream habitats and fauna. Major emphasis on stream habitat evaluation, regulated stream flow, biotic, integrity, and watershed management.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): BIOL 4004

Corequisite(s):

FIW 5894:

Final Examination

NONE

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

FIW 5954:

Study Abroad

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

FIW 5974:

Independent Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Independent Study, VI

146 Instruction Type(s): Independent Study, VI

Prerequisite(s):

Corequisite(s):

FIW 5984:

Special Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

FIW 5994:

Research and Thesis

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research, Online Research

Instruction Type(s): Research, Online Research

Prerequisite(s):

Corequisite(s):

FIW 6004:

Topics: Fisheries & Wildlife

Readings and discussion in a specific area of fisheries and wildlife conservation. Topic will vary and course may be taken for credit more than once. Background in fisheries or wildlife required. Variable credit course. Graduate standing required. I, II.

Credit Hour(s): 0 TO 12

Lecture Hour(s): 0 TO 12

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

FIW 6114:

Applied Conservation Genetics

Use of analytical tools and software packages to characterize population genetics of terrestrial and aquatic animals for application in fisheries, wildlife, and endangered species management. Population genetic processes and theory, laboratory methods for screening molecular markers (mitochondrial and nuclear DNA markers), analysis of genetic data using various computer software programs, and interpretation of statistical results.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): FIW 5114

Corequisite(s):

FIW 6984:

Special Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

FIW 7994:

Research and Dissertation

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research, Online Research

Instruction Type(s): Research, Online Research

Prerequisite(s):

Corequisite(s):

FORESTRY

Bradley Sullivan, Head

Professors: Gregory Amacher; Wallace Aust; Harold Burkhardt; Robert Hull; Stephen Schoenholtz; John Seiler; Bradley Sullivan; Randolph Wynne;

Associate Professors: Michael Bolding; Amy Brunner; Carolyn Copenheaver; Jason Holliday; Kevin McGuire; John Munsell; Philip Radtke; Marc Stern; Brian Strahm; Valerie Thomas; Phillip Wiseman;

Assistant Professors: Scott Barrett; David Carter; Thomas Coates; Kelly Cobourn; Daniel McLaughlin; Stella Schons Do Valle; Michael Sorice; Robert Thomas;

Affiliated Faculty: Jeffrey Marion;

Julian N. Cheatham Professor of Forestry: Gregory Amacher;

University Distinguished Professor: Harold Burkhardt;

Shelton H. Short, Jr., Professor of Forestry: John Seiler;

Graduate Contact: masmith5@vt.edu

Website: <http://www.frec.vt.edu>

Virginia Tech's Department of Forest Resources and Environmental

Conservation is one of the leading programs in natural resource management in the United States. Our teaching and research focus on the latest applications to uncover the science needed to manage forests and other natural resources. Our programs are diverse and approach critical natural resource issues from many disciplinary perspectives. From protected areas management and economic policy to forest soil productivity, urbanization, and genomics, we seek to discover new knowledge and technology to address the global challenges to come.

SPECIAL FACILITIES

Cheatham Hall (JCH): The College of Natural Resources and Environment administrative and advising offices are located in Cheatham Hall, which houses the Departments of Forest Resources and Environmental Conservation, Sustainable Biomaterials, Fish and Wildlife Conservation, and the Virginia Water Resources Research Center. Teaching classrooms, laboratories, and faculty and graduate offices are located in Cheatham Hall. Latham Hall: The Latham Agriculture and Natural Resources Building houses several faculty offices and laboratories in the Department of Forest Resources and Environmental Conservation. For information on analytical lab spaces and equipment in Latham, please contact Dave Mitchem at dmitchem@vt.edu. Center for Environmental Analytics and Remote Sensing (CEARS): CEARS is located in 217 Cheatham Hall. The laboratory houses 22 networked precision workstations, a high-end large-format printer, and field equipment to support in situ measurements. The Center also provides access to an extensive archive of Landsat and MODIS scenes as well as software for image processing, compiling, statistical analysis, and GIS. For access to the CEARS Lab, please see Les Fuller in 216 Cheatham to request and complete an account request form. Reynolds Homestead Forest Resources Research Center: The Reynolds Center is a 710-acre research and education center located in the Virginia Piedmont 70 miles southeast of Blacksburg in Critz, Virginia. The Center houses laboratory space, greenhouses, and a continuing education center that support research and education in the Department of Forest Resources and Environmental Conservation. Fishburn School Forest: The Fishburn is a 1,353-acre demonstration forest, located 10 minutes from campus. The forest is comprised of Appalachian hardwood and mixed pine-hardwood and supports field research, teaching, and demonstration projects in the Ridge and Valley physiographic region. Equipment Room: The Department maintains a supply of field equipment for use in teaching and research. For checkout procedures and access, contact Tal Roberts at talr@vt.edu or Kathie Hollandsworth in 228 Cheatham. Sample Preparation and Storage Facilities: The Department maintains multiple facilities for equipment storage and processing and storage of field samples. For use procedures and access, contact Dave Mitchem at dmitchem@vt.edu. Forest Harvesting Laboratory: The 2,400-square foot Forest Harvesting Lab is located in Blacksburg adjacent to the Virginia Tech campus. The lab has a fully equipped machine shop used to fabricate new machine designs and support equipment used in field research in the Department. For procedures and access, contact Tal Roberts at talr@vt.edu.

FREC Facilities

Cheatham Hall (JCH): The College of Natural Resources and Environment administrative and advising offices are located in Cheatham Hall, which houses the Departments of Forest Resources and Environmental Conservation, Sustainable Biomaterials, Fish and Wildlife Conservation, and the Virginia Water Resources Research Center. Teaching classrooms, laboratories, and faculty and graduate offices are

located in Cheatham Hall. Latham Hall: The Latham Agriculture and Natural Resources Building houses several faculty offices and laboratories in the Department of Forest Resources and Environmental Conservation. For information on analytical lab spaces and equipment in Latham, please contact Dave Mitchem at dmitchem@vt.edu. Center for Environmental Analytics and Remote Sensing (CEARS): CEARS is located in 217 Cheatham Hall. The laboratory houses 22 networked precision workstations, a high-end large-format printer, and field equipment to support in situ measurements. The Center also provides access to an extensive archive of Landsat and MODIS scenes as well as software for image processing, compiling, statistical analysis, and GIS. For access to the CEARS Lab, please see Les Fuller in 216 Cheatham to request and complete an account request form. Reynolds Homestead Forest Resources Research Center: The Reynolds Center is a 710-acre research and education center located in the Virginia Piedmont 70 miles southeast of Blacksburg in Critz, Virginia. The Center houses laboratory space, greenhouses, and a continuing education center that support research and education in the Department of Forest Resources and Environmental Conservation. Fishburn School Forest: The Fishburn is a 1,353-acre demonstration forest, located 10 minutes from campus. The forest is comprised of Appalachian hardwood and mixed pine-hardwood and supports field research, teaching, and demonstration projects in the Ridge and Valley physiographic region. Equipment Room: The Department maintains a supply of field equipment for use in teaching and research. For checkout procedures and access, contact Tal Roberts at talr@vt.edu or Kathie Hollandsworth in 228 Cheatham. Sample Preparation and Storage Facilities: The Department maintains multiple facilities for equipment storage and processing and storage of field samples. For use procedures and access, contact Dave Mitchem at dmitchem@vt.edu. Forest Harvesting Laboratory: The 2,400-square foot Forest Harvesting Lab is located in Blacksburg adjacent to the Virginia Tech campus. The lab has a fully equipped machine shop used to fabricate new machine designs and support equipment used in field research in the Department. For procedures and access, contact Tal Roberts at talr@vt.edu.

DEGREES OFFERED

MS Degree

TOEFL

Paper: (550.0)

Computer: (213.0)

iBT: (80.0)

GRE

General Test: Verbal, Quantitative, Analytical

The department offers three degrees: Master of Forestry (M.F.), Master of Science (M.S.) in Forestry and Forest Products, and Doctor of

Philosophy (Ph.D.) in Forestry and Forest Products. The M.S. and Ph.D. degrees require students to prepare a thesis or dissertation, and considerable time spent working for these degrees is devoted to research. The M.F. degree is a professional, non-research degree for those who wish to expand their post-baccalaureate education. Master of Forestry The M.F. is a non-research degree intended to serve the needs of (1) those who have a prior forestry degree and who wish to enhance their knowledge and skills or (2) those who have no previous degree in forestry. In addition to formal course work at the graduate and senior undergraduate levels that is commensurate with the objectives of the student's degree program, a substantive paper worth three to six hours of academic credit is required. A minimum of 30 credit hours in formal course work, inclusive of hours credited towards the degree paper, must be passed with a minimum GPA of 3.0 for courses in the program of study. Students entering the M.F. program without prior forestry education must demonstrate competency in appropriate topics such as forest biology, dendrology, or forest ecology in addition to completing the usual M.F. requirements. At the discretion of their graduate committees, these students must either take undergraduate forestry courses to meet these competency requirements or demonstrate knowledge through alternate means such as experience or prior coursework. The M.F. student must pass a comprehensive oral examination covering his/her course work and the degree paper. All Graduate School requirements apply as to the nature and timing of the candidate's final examination. Master of Science The M.S. is a research-based degree. Students work closely with a faculty advisor and graduate committee on original research. Advanced coursework is expected in the areas of expertise required to complete the research project. Students complete a thesis and are expected to publish their research results in peer-reviewed scientific journals at the completion of their degree. Graduates are prepared to continue their professional careers or undertake further study through a Ph.D. program. All Graduate School requirements apply regarding the number of credits and level of courses required on a student's Plan of Study. M.S. students must complete a research working plan by the end of the second academic semester. Guidelines for the preparation and submittal of the working plan are listed in the College of Natural Resources and Environment (CNRE) Graduate Program Procedures. M.S. students must pass a final exam. The examination will be a defense of the thesis and an assessment of the student's understanding of appropriate forestry-related subjects.

PhD Degree

TOEFL

Paper: (550.0)

Computer: (213.0)

iBT: (80.0)

GRE

General Test: Verbal, Quantitative, Analytical

The department offers three degrees: Master of Forestry (M.F.), Master of Science (M.S.) in Forestry and Forest Products, and Doctor of Philosophy (Ph.D.) in Forestry and Forest Products. The M.S. and Ph.D. degrees require students to prepare a thesis or dissertation, and considerable time spent working for these degrees is devoted to research. The M.F. degree is a professional, non-research degree for those who wish to expand their post-baccalaureate education. Doctor of Philosophy Each Ph.D. student must complete a minimum of 90 credit hours of graduate study and a dissertation. The Plan of Study must meet minimum Graduate School requirements; in addition, a student's advisory committee may add specific requirements needed for an individual student's academic development. Ph.D. students must

complete a research working plan by the end of the third academic semester. Guidelines for the preparation and submittal of the working plan are listed in the College of Natural Resources and Environment (CNRE) Graduate Program Procedures. All Ph.D. students in the Department of Forest Resources and Environmental Conservation must demonstrate minimum competency in statistics (see CNRE Graduate Program Procedures for requirements). Doctoral students may be required to take a qualifying exam. The exact nature of the exam is determined by faculty within the student's chosen discipline. The purposes of this examination or assessment are to (1) evaluate the student's comprehensive knowledge in his/her field or study, (2) identify any deficiencies in the student's background and recommend supplementary course work or self-study improvements, and (3) evaluate the student's ability to successfully complete the doctoral degree. A required preliminary exam, oral and/or written, is conducted by the student's advisory committee. This exam is comprehensive in nature and is intended to test a student's ability to integrate, synthesize, and apply concepts, facts, and techniques in solving new and complex problems associated with forest management and use. The student may be tested on any aspect of forest science, the philosophy of science, and research methodology. The final exam is primarily a defense of the dissertation, but other areas of science may be included. Ph.D. students are expected to publish their research results in peer-reviewed scientific journals at the completion of their degree.

GRADUATE COURSES (FREC)

FREC 5004:

Graduate Seminar

Special topics, critical reviews, and discussions of pertinent literature throughout a wide range of subject areas in forestry. May be repeated.

Credit Hour(s): 1

Lecture Hour(s): 1

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

FREC 5014:

Research Ethics & Integrity in Forest Resources & Environmental Conservation

Examination of scholarly ethics and integrity in the responsible conduct of research in forest resources and environmental conservation.

Professional standards of science, including mentoring, authorship, peer review, data sharing and ownership, record keeping, research misconduct, and conflict of interest. Pre: Graduate standing.

Credit Hour(s): 1

Lecture Hour(s): 1

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

FREC 5024:**Coupling Social and Ecological Systems**

Human-environment relationships in research. Current paradigms in environmental conservation. Methods and approaches to conducting coupled human-environment research and management. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

FREC 5104 (GEOG 5104):**Seminar in Remote Sensing & Geographic Information Systems**

Interdisciplinary seminar devoted to current research in the fields of remote sensing, Geographic Information Systems, and related topics. Seminars, workshops, and presentations conducted by students, faculty, and visitors. Pre: Graduate standing.

Credit Hour(s): 1

Lecture Hour(s): 1

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

FREC 5114:**Geospatial Programming and Analytical Methods**

Common programming techniques with emphasis on application to remotely sensed and geospatial data. Input/output and formatting. Raster and feature operations from a command line using serial and parallel processing methods. Management and integration of large and varied datasets with emphasis on incorporating new data. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

FREC 5114G:**Advanced Information Technologies for Natural Resource Management**

Course will introduce students to the theory and applications of database management systems (DBMS) and geographic information systems

(GIS). Uses, challenges, and limitations of these technologies in natural resource management application will be discussed.

Credit Hour(s): 3

Lecture Hour(s): 2

Instruction Type(s): Lab, Lecture, Online Lecture

Instruction Type(s): Lab, Lecture, Online Lecture

Prerequisite(s): FREC 2214 (UG) OR GEOG 2314 (UG)

Corequisite(s):

FREC 5134:**Environmental Conflict Management**

Seminar-styled course will develop and explore theories and practical approaches to understanding and managing modern environmental conflicts, with an emphasis on the processes and structures unique to the United States. Causes, controls, and potential remedies for managing the intense conflicts routinely associated with natural resource management and environmental regulation. Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

FREC 5144 (CSES 5144):**Watershed Hydrology**

Physical concepts of hydrological processes that affect age, origin, cycling, and flowpaths of water within watersheds. Analysis of current and historical research methods. Hydrological science as an interdisciplinary topic. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

FREC 5154 (GEOG 5154):**Hyperspectral Remote Sensing**

Theory of spectroscopy and spectrometry from portable spectroradiometers to airborne and spaceborne hyperspectral sensors as relevant to natural resource applications, including vegetation species identification and vegetative health, soil and peat properties, mineral and geothermal characteristics, and water applications. Practical investigation of research tools and techniques used to analyze hyperspectral data. Prerequisite: Graduate Standing Required

Lecture Hour(s): 2

Instruction Type(s): Lab, Lecture, Online Lecture

Instruction Type(s): Lab, Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

FREC 5164:

Population Genomics

Contemporary sequencing, genotyping, and analytical approaches to understanding the causes and consequences of genomic variation that impinges on fitness, productivity, and health of natural and managed populations of plants and animals. Neutral population and evolutionary genetic processes, methods to identify the molecular targets of natural selection, genetic variation relevant to fitness-related traits, software tools relevant to genomic data analysis in a population genetic context.

Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

FREC 5224:

Forest Biometry

Theory and practice involved in the measurement and modeling of the growth and yield of forest trees and stands

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): FREC 3215, FREC 3216, STAT 5606, STAT 5616

Corequisite(s):

FREC 5254:

Remote Sensing of Natural Resources

Philosophy and rationale of remote sensing as a part of the resource management process; comparisons of analogic and digital sensors; sensor selection and proper use; accuracy assessment; signature development; and identification of factors which affect the quality of remotely sensed information.

Credit Hour(s): 0 OR 3

Lecture Hour(s): 0 OR 2

Instruction Type(s): Lab, Lecture, Online Lecture

Instruction Type(s): Lab, Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

FREC 5264:

GIS Applications in Natural Resource Management

Acquiring and using publicly available natural resources data sources. Methods and algorithms for terrain modeling and landscape metrics. Evaluation of the impacts of data errors and variability on analysis results, including sensitivity analysis of GIS-based resource assessments. Special issues related to temporal data and the management of natural resources information systems.

Credit Hour(s): 0 OR 3

Lecture Hour(s): 0 OR 2

Instruction Type(s): Lab, Lecture, Online Lecture

Instruction Type(s): Lab, Lecture, Online Lecture

Prerequisite(s): FREC 4214 OR GEOG 4084

Corequisite(s):

FREC 5334:

Plant Water Relations

Properties and status of water in the plant and thermodynamics in relation to water and solute movement; measuring water deficits and drought tolerance; and transpiration and stomatal action.

Credit Hour(s): 0 OR 3

Lecture Hour(s): 0 OR 2

Instruction Type(s): Lab, Lecture, Online Lecture

Instruction Type(s): Lab, Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

FREC 5354:

Soil Science and Biogeochemistry

Foundations of soil science and biogeochemistry. Concepts in soil and landscape evolution; elemental cycling; soil-plant-microbe interactions; soil sampling and analysis; and relationships among physical, chemical, and biological properties and processes. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

FREC 5374:

Advanced Forest Ecology

Advanced topics in forest ecology, including: forest populations, forest community dynamics, forest community structure and analysis, forest productivity on a global scale, ecology of forest landscapes, spatial

Credit Hour(s): 0 OR 3

Lecture Hour(s): 0 OR 2

Instruction Type(s): Lab, Lecture, Online Lecture

Instruction Type(s): Lab, Lecture, Online Lecture

Prerequisite(s): FREC 3314, MATH 2016, STAT 5606, STAT 5616

Corequisite(s):

FREC 5374G:

Advanced Forested Wetlands

Classifications, jurisdictional delineation, and management options of forested wetlands. Relationship of hydrology, soils, and vegetation to ecosystem processes, societal values, and management with regard to environmental and legal considerations and best management practices.

Emphasis is on forested wetlands in the southern U.S. but national and international wetlands are included. Data analysis, interpretations, and report for field trips are required for graduate credit. Fee \$113. Graduate Standing required.

Credit Hour(s): 3

Lecture Hour(s): 2

Instruction Type(s): Lab, Lecture, Online Lecture

Instruction Type(s): Lab, Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

FREC 5384:

Forest Biology and Ecology for Educators

This online course is designed to provide educators with an understanding of the specifics of forest ecology and tree biology. Topics include identification of approximately 80 commonly found tree species, tree growth and development, woody plant reproduction and propagation, carbon and water uptake, dormancy and coldhardiness, site productivity and forest succession, forest soils, and silvicultural practices in managed forests. This class is offered online during a 10 week period that extends over both Summer I and II sessions. This course is not available to graduate students enrolled in Forestry programs.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

FREC 5416:

Advanced Forest Resource Management and Economics

5415: Application of microeconomics to solving forest resource problems. Emphasis on forest products demand and supply analysis,

forest products marketing, forest capital theory, and interregional and international trade in forest products. 5416: Impacts of economic and physical variables upon forest appraisal and management decisions. Valuation of nonmarket goods and economics of multiple-use.

Application of operations research tools in evaluating forest management alternatives in public and private forest planning. I

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): FREC 3414, FREC 4424

Corequisite(s):

FREC 5454G:

Advanced Urban Community Forestry

Ecological, socioeconomic, and technical aspects of planning, managing, and conserving urban forests. Historical, contemporary, and global context of urban forestry. Contributions of trees and associated greenspaces to urban sustainability and community well-being. Methods of urban forest assessment and valuation. Roles of government, private industry, and community stakeholders in shaping urban forests.

Extensive experiential learning with field techniques and technology.

Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 2

Instruction Type(s): Lab, Lecture, VB, Online Lecture

Instruction Type(s): Lab, Lecture, VB, Online Lecture

Prerequisite(s):

Corequisite(s):

FREC 5464:

Social Science Research Methods in Natural Resources

Social science research design and methods for students studying natural resource management. Addresses the unique and interdisciplinary nature of social science research related to complex natural resource problems. Guides students through the development of research questions into detailed research proposals that address human dimensions of natural resource management. Students own research topics will provide examples for in-class discussion of research design.

Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

FREC 5474:**Adv Stud in Urban For Ecosys**

The nature and dynamics of urban ecosystems with emphasis on the role of urban forests. Examines the interactions of urban forests with the built environment at multiple scales and from multiple disciplinary perspectives. Management influence on ecosystem processes and approaches to estimating urban forest ecosystem services from urban cores to pre-urban development. Pre-requisite: Graduate Standing required

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

FREC 5494:**Natural Resource Research Procedures**

An examination of concepts and philosophies of science and research as applied to forestry and related renewable natural resource research programs. Emphasis is on scientific procedure, ethics, and responsibility. Attention is also paid to the specifics of establishing research projects, contracts, and grants and carrying them out. Consent required.

Credit Hour(s): 2

Lecture Hour(s): 2

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

FREC 5714G:**Advanced Harvesting Systems Evaluation**

Advanced principles and techniques for evaluating harvesting machines and systems design, application, productivity, and financial performance. Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

FREC 5784G:**Advanced Wetland Hyrdology and Biogeochemistry**

Water flows creating wetland hydrologic regime. Hydrologic controls on wetland processes. Linkages between hydrology and biogeochemical cycles. Carbon, nitrogen, phosphorus, and other element cycles within

and across wetland boundaries. Field methods to assess hydrologic regime and biogeochemical cycles. Ecosystems services from hydrologic and biogeochemical processes. Applications of wetland hydrology and biogeochemistry in wetland restoration, delineation, and creation. Pre: Graduate Standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

FREC 5884:**Topics in Forest Resources and Environmental Conservation**

Topics in forest resources and environmental conservation. Evaluation of literature and/or a critical appraisal of methods/approaches of analysis related to contemporary issues. May be repeated with different content for a maximum of 16 credits. Pre: Graduate standing.

Credit Hour(s): 1 TO 4

Lecture Hour(s): 1 TO 4

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

FREC 5894:**Final Examination**

NONE

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

FREC 5904:**Project and Report**

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research

Instruction Type(s): Research

Prerequisite(s):

Corequisite(s):

FREC 5954:

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

FREC 5974:

Independent Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Independent Study

Instruction Type(s): Independent Study

Prerequisite(s):

Corequisite(s):

FREC 5984:

Special Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

FREC 5994:

Research and Thesis

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research

Instruction Type(s): Research

Prerequisite(s):

Corequisite(s):

FREC 6214 (GEOG 6214):

Forestry Lidar Applications

Theoretical underpinning of established and emerging research using light detection and ranging (lidar) technology for forestry applications including detailed terrain mapping and digital elevation models, canopy height modeling, prediction of forest biophysical parameters, forest physiology and the canopy light regime, watershed mapping and stream modeling, ecological modeling, landscape classifications, and wildlife habitat. Advanced research tools and techniques used to analyze lidar

data for different applications. Graduate standing required.

Credit Hour(s): 0 OR 3

Lecture Hour(s): 0 OR 2

Instruction Type(s): Lab, Lecture, Online Lecture

Instruction Type(s): Lab, Lecture, Online Lecture

Prerequisite(s): (FREC 5254 OR FOR 5254), (FREC 5264 OR FOR 5264), GEOG 5034

Corequisite(s):

FREC 6984:

Special Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

FREC 7994:

Research and Dissertation

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research

Instruction Type(s): Research

Prerequisite(s):

Corequisite(s):

GEOGRAPHY

Thomas Crawford, Chair

Professors: James Campbell; Laurence Carstensen; Thomas Crawford; Andrew Ellis; Korine Kolivras; Lynn Resler;

Associate Professors: Timothy Baird; Luke Juran; Lisa Kennedy; Robert Oliver; Thomas Pingel; Yang Shao;

Assistant Professors: Anamaria Bukvic; Craig Ramseyer; Stephanie Zick;

General Contact: geog@vt.edu

Graduate Site: <http://geography.vt.edu/PROGRAMS/graduate.htm>

The graduate program in geography consists of an MS degree in Geography and a PhD. degree in Geospatial and Environmental Analysis. The MS degree develops specialists for academic, agency and industry positions though emphasis on: Making appropriate use of methods for geographic inquiry to determine, to analyze, and to interpret

spatial and temporal patterns and processes Identifying debates and gaps in the current literature to define an original research question Conducting research, collecting primary or secondary data, defending, and presenting their findings in publishable form At the doctoral level, the emphasis is on preparation for research careers with agencies or in academia as: students will demonstrate advanced proficiency in geospatial analysis in an interdisciplinary environment students will conduct and defend independent research that contributes to the literature students will identify and apply appropriate statistical methods for specific research questions

SPECIAL FACILITIES

The department is housed in Major Williams Hall on the upper quad of the campus. The department occupies the entire first floor of the building with faculty offices and laboratory space.

Biogeography Laboratory

Two Biogeography Laboratories offer advanced facilities for the study of recent and long-term environmental history and vegetation change through analysis of lake sediment and/or tree rings. Equipment resources include refrigerated storage, computers, several Leica compound microscopes with digital imaging capability used in paleoecological research, a Colinvaux-Vohnout Sediment Coring system, Fume Hood, isotemp Furnace, and a Velmex tree-ring measurement system used in dendrochronological analysis.

Geospatial Laboratory

The Department's GIS Laboratory offers 18 Windows 7 workstations for classes and for research, including specialized systems for GIS, cartography, and remote sensing. Software packages include the complete suite of ArcGIS, ArcEngine, Surfer, Python, Visual Studio, Trimble GPS Pathfinder, ERDAS IMAGINE, ENVI/IDL, and eCognition.

Physical Geography Laboratory

The Physical Geography Lab includes equipment for soil sampling, sample desiccation and microscopic viewing.

DEGREES OFFERED

MS Degree

Offered In (Blacksburg)

TOEFL

Paper: (550.0)

Computer: (213.0)

iBT: (80.0)

GRE

General Test: Verbal (154.0), Quantitative (156.0)

The MS program in geography emphasizes developing professional competence in the tools, substance, methodology, and theory of the discipline. Thesis and non-thesis options in the 30 semester hour program prepare students for a variety of careers in teaching, research and planning organizations, business and government.

PhD Degree

Offered In (Blacksburg)

TOEFL

Paper: (550.0)

Computer: (213.0)

iBT: (80.0)

GRE

General Test: Verbal (154.0), Quantitative (156.0)

The Geospatial and Environmental Analysis PhD. degree is housed in the College of Natural Resources and Environment and the Department of Geography is the home to about 60% of its students. The degree requires that students become proficient in the use of Geographic Information Systems and Remote Sensing and that their research make use of those tools in environmentally oriented research.

GRADUATE COURSES (GEOG)

GEOG 5004:

Current Geographic Research

Current research in geography and in allied fields. Presentations and workshops conducted by students, faculty, and on-and off-campus visitors. Pre: Graduate standing.

Credit Hour(s): 1

Lecture Hour(s): 1

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

GEOG 5014:

Geographic Theory and Research

Study of how physical geography, human ecological concerns, and the spatial perspective have been synthesized into a unified academic discipline. Formulation of geographic research problems, including collection, organization, and analysis of geographic data.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

GEOG 5034:

Analysis of Spatial Data

Methods of describing and analyzing spatial distributions, including spatial autocorrelation, quadrat analysis, trend surface analysis, and

methods of map comparison. Applications to student research problems.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

GEOG 5064:

Elements of GIS

Foundations and applications of Geographic Information Systems (GIS); geographic coordinate systems, Cartesian map projections, spatial data sources, efficient GIS data structures, map representations, and spatial applications of GIS. Pre: Graduate Standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

GEOG 5074G:

Advanced Medical Geography

Geographic patterns of disease and health care at various scales. Study of interactions between the physical environment and health. Analysis of spatial patterns associated with HIV/AIDS epidemic. Examination of health implications of social and cultural variation in developed and developing contexts. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

GEOG 5084G:

Advanced Modeling with Geographic Information Systems

Use of automated systems for geographic data collection, digitization, storage, display, modeling and analysis. Basic data flow in GIS modeling applications. Development of proficiency in the use of current GIS software. Pre: Graduate Standing.

Credit Hour(s): 3

Lecture Hour(s): 1

Instruction Type(s): Lab, Lecture, VB, Online Lecture

Instruction Type(s): Lab, Lecture, VB, Online Lecture

Prerequisite(s):

Corequisite(s):

GEOG 5104 (FREC 5104):

Seminar in Remote Sensing & Geographic Information Systems

Interdisciplinary seminar devoted to current research in the fields of remote sensing, Geographic Information Systems, and related topics.

Seminars, workshops, and presentations conducted by students, faculty, and visitors. Pre: Graduate standing.

Credit Hour(s): 1

Lecture Hour(s): 1

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

GEOG 5114:

Geospatial Programming and Environmental Conservation

Common programming techniques with emphasis on application to remotely sensed and geospatial data. Input/output and formatting.

Raster and feature operations from a command line using serial and parallel processing methods. Management and integration of large and varied datasets with emphasis on incorporating new data. Pre: Graduate standing

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

GEOG 5124:

Aerial Photointerpretation and Analysis

Principles, history, and methods of aerial photographic interpretation.

Introduction to photographic systems and application to aerial photography. Human dimension to photointerpretation. Applications to varied fields of knowledge such as land-use mapping, earth sciences, forestry, agriculture, history and archaeology, and military and strategic studies.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): GEOG 4354, FOR 4214

Corequisite(s):

GEOG 5134 (GEOS 5844):

Advanced Interdisciplinary Issues and Ethics in Water Resources

156 Issues and ethics related to water resources, water as a hazard upon

human (infrastructure, economy) and ecological (rivers, groundwater) systems, water- and vector-borne disease, climate change, dams, and eutrophication. Multidimensionality of water resources. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

GEOG 5154 (FREC 5154):

Hyperspectral Remote Sensing

Theory of spectroscopy and spectrometry from portable spectroradiometers to airborne and spaceborne hyperspectral sensors as relevant to natural resource applications, including vegetation species identification and vegetative health, soil and peat properties, mineral and geothermal characteristics, and water applications. Practical investigation of research tools and techniques used to analyze hyperspectral data. Prerequisite: Graduate Standing Required

Credit Hour(s): 3

Lecture Hour(s): 2

Instruction Type(s): Lab, Lecture, Online Lecture

Instruction Type(s): Lab, Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

GEOG 5214:

Health and the Global Environment

Examination of human-environment relations in the context of health and disease using a global perspective. Investigation of dynamic interactions between humans and the total environment, including the physical, biological, cultural, political, and economic environments, in relation to disease. Analysis of geographic variations in health, disease, and health care delivery, including differences between developed and developing regions and within a variety of human and physical environments.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

GEOG 5224G:

Advanced Tracking Environmental Change

Multidisciplinary approaches to documenting and understanding past environmental change. Methods used to unravel the physical and human

drivers of historical and longer-term changes in climate, vegetation, and fire patterns. Application of environmental change data and insights to improve land and conservation management under changing climates.

Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

GEOG 5314:

Advanced Spatial Analysis in Geographic Information Systems

Theory and application of geographic information systems. Spatial data handling and analysis to facilitate decision-making through the communication of geographic information. Development of such systems from existing data sources using both packaged and student produced software systems.

Credit Hour(s): 0 OR 3

Lecture Hour(s): 0 OR 2

Instruction Type(s): Lab, Lecture, Online Lecture

Instruction Type(s): Lab, Lecture, Online Lecture

Prerequisite(s): GEOG 4084

Corequisite(s):

GEOG 5334G:

Advanced Geospatial Information Technology for Land Change Modeling

Analysis of the spatio-temporal patterns of land use and Land Cover Change (LULCC) as observed in satellite images. Tropical deforestation, urbanization, and agricultural intensification. Rates and patterns of LULCC linked to biophysical and socio-economic drivers. Impacts of land change with respect to local climate, biodiversity, water yield and quality, and ecosystem services.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): GEOG 5084G

Corequisite(s):

GEOG 5354G:

Advanced Remote Sensing

Theory and methods of remote sensing. Practical exercises in interpretation of aerial photography, satellite, radar, and thermal infrared imagery. Digital analysis, image classification, and evaluation.

Applications in earth sciences, hydrology, plant sciences, and land use

studies. Field project and report. Review of current research literature.

Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 2

Instruction Type(s): Lab, Lecture, Online Lecture

Instruction Type(s): Lab, Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

GEOG 5364:

GIS Applications in Natural Resource Management

Acquiring and using publicly available natural resources data sources.

Methods and algorithms for terrain modeling and landscape metrics.

Evaluation of the impacts of data errors and variability on analysis results, including sensitivity analysis of GIS-based resource assessments. Special issues related to temporal data and the management of natural resources information systems.

Credit Hour(s): 0 OR 3

Lecture Hour(s): 0 OR 2

Instruction Type(s): Lab, Lecture, Online Lecture

Instruction Type(s): Lab, Lecture, Online Lecture

Prerequisite(s): FOR 4214 OR GEOG 4084

Corequisite(s):

GEOG 5374G:

Adv Remote Sensing & Phenology

This course focuses on the analysis of the spatio-temporal of the vegetated land surface as observed in satellite images. Phenological events, such as the first openings of leaf and flower buds, are good indicators of the impact of local and global climate change. The focus of this course will be on satellite image time series used in the derivation of land surface phenology, the appearance and development of phenology other global regions, and the methods developed for the monitoring of phenology with satellite imagery. A major theme will be causes of spatio-temporal changes of phenological events and the effect of global climate change. Pre-requisite: Graduate Standing required

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): GEOG 5354

Corequisite(s):

GEOG 5384:

Programming for Geographic Information Systems

Computational methods of map analysis with the ArcGIS Geographic Information System. Scripting and Visual Basic.NET programming using

Environmental Systems Research Institutes ArcObjects library for customization of GIS software to meet research and analytical needs for both the desktop and the web. Pre: 5084G and computer programming experience.

Credit Hour(s): 4

Lecture Hour(s): 3

Instruction Type(s): Lab, Lecture, Online Lecture

Instruction Type(s): Lab, Lecture, Online Lecture

Prerequisite(s): GEOG 5084G

Corequisite(s):

GEOG 5394G:

Web Mapping

Use of web mapping technologies for geographic data collection, storage, analysis, and display. Web mapping topics include history and context, spatial data infrastructures, hardware and software architectures, Open Geospatial Consortium standards, mapping APIs, virtual globes, user-centric design, web cartography. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

GEOG 5404G:

Advanced Geovisualization

Advanced topics in digital and dynamic map production, emphasizing concepts in advanced cartographic design, information visualization, and human-computer interaction. Topics include cartograms, computer aided design, animation, lidar and photogrammetric point cloud visualization, Web Geographic Information Systems, terrain visualization, and virtual geographic environments. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

GEOG 5414G:

Advanced Climate Change and Societal Impacts

Impacts of climate change on different societies. Concepts of adaptation, vulnerability, and resilience. Notions of complexity, uncertainty, and thresholds related to climate change outcomes. Case study analysis of communities affected by climate change. Understanding future and

assessing climate vulnerability across various spatiotemporal scales. Scenario planning, foresight analysis, and interactive digital tools. Pre: Graduate standing.
Credit Hour(s): 3
Lecture Hour(s): 3
Instruction Type(s): Lecture, Online Lecture
Instruction Type(s): Lecture, Online Lecture
Prerequisite(s):
Corequisite(s):

GEOG 5424 (GIA 5404):

Topics in Political Geography

Territorial basis of political systems, political processes, and political behavior from local to global scales; evolution of contemporary political geographic patterns, territorial divisions, and process of partitioning the earth.
Credit Hour(s): 3
Lecture Hour(s): 3
Instruction Type(s): Lecture, Online Lecture
Instruction Type(s): Lecture, Online Lecture
Prerequisite(s):
Corequisite(s):

GEOG 5444:

Topics in Physical Geography

Investigation of selected advanced topics in physical geography, such as the history of inquiry in the field of physical geography, systems theory, the scientific method in physical geography, scale, complexity, environmental change, and problems of explanation and extrapolation. Even years, May be repeated for credit for a maximum of 9 credit hours with different content. Graduate standing required.
Credit Hour(s): 3
Lecture Hour(s): 3
Instruction Type(s): Lecture, Online Lecture
Instruction Type(s): Lecture, Online Lecture
Prerequisite(s):
Corequisite(s):

GEOG 5514G:

Advanced Tropical Meteorology

Tropical weather and climate topics: remote sensing and observations; tropical climatology, including regional and large-scale circulations, monsoons, and the El Niño/Southern Oscillation; tropical convection, including the clouds in the subtropics, deep convection in the equatorial region, and tropical cloud clusters and thunderstorms; and tropical cyclones, including their structure, intensity, lifecycle, and formation. Pre: Graduate standing.

Credit Hour(s): 3
Lecture Hour(s): 3
Instruction Type(s): Lecture, Online Lecture
Instruction Type(s): Lecture, Online Lecture
Prerequisite(s):
Corequisite(s):

GEOG 5654:

The Global Division of Labor

Theory and research on the globalization of the division of labor during the recent past as well as over the past several centuries. Examines the development of the capitalist world-system including the role of technological forces; the roles of transnational corporations and states in the global economy; the effects of globalization on work and quality of life in the U.S., other developed countries, and the Third World; analyses of globalization in the manufacturing and service sectors; and possible solutions for problems associated with globalization.
Credit Hour(s): 3
Lecture Hour(s): 3
Instruction Type(s): Lecture, Online Lecture
Instruction Type(s): Lecture, Online Lecture
Prerequisite(s):
Corequisite(s):

GEOG 5764G:

Advanced International Development Planning and Policy

Examination of major development theories and contemporary issues and characteristics of low-income societies (industrialization, urbanization, migration, rural poverty, hunger, foreign trade, and debt) that establish contexts for development planning and policy making. Graduate standing required.
Credit Hour(s): 3
Lecture Hour(s): 3
Instruction Type(s): Lecture, Online Lecture
Instruction Type(s): Lecture, Online Lecture
Prerequisite(s):
Corequisite(s):

GEOG 5894:

Final Examination

NONE
Credit Hour(s): 3
Lecture Hour(s): 3
Instruction Type(s): Lecture, Online Lecture
Instruction Type(s): Lecture, Online Lecture
Prerequisite(s):
Corequisite(s):

GEOG 5904:

Project and Report

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research

Instruction Type(s): Research

Prerequisite(s):

Corequisite(s):

GEOG 5954:

Study Abroad

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

GEOG 5974:

Independent Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Independent Study

Instruction Type(s): Independent Study

Prerequisite(s):

Corequisite(s):

GEOG 5984:

Special Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

GEOG 5994:

Research and Thesis

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research

Instruction Type(s): Research

Prerequisite(s):

Corequisite(s):

GEOG 6214 (FREC 6214):

Forestry Lidar Applications

Theoretical underpinning of established and emerging research using light detection and ranging (lidar) technology for forestry applications including detailed terrain mapping and digital elevation models, canopy height modeling, prediction of forest biophysical parameters, forest physiology and the canopy light regime, watershed mapping and stream modeling, ecological modeling, landscape classifications, and wildlife habitat. Advanced research tools and techniques used to analyze lidar data for different applications. Graduate standing required.

Credit Hour(s): 0 OR 3

Lecture Hour(s): 0 OR 2

Instruction Type(s): Lab, Lecture, Online Lecture

Instruction Type(s): Lab, Lecture, Online Lecture

Prerequisite(s): GEOG 5034, (FOR 5254 OR FREC 5254), (FOR 5264 OR FREC 5264)

Corequisite(s):

GEOG 6984:

Special Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

GEOG 7994:

Research and Dissertation

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research

Instruction Type(s): Research

Prerequisite(s):

Corequisite(s):

GEOSPATIAL AND ENVIRONMENTAL ANALYSIS

Thomas Crawford, Chair

Professors: James Campbell; Laurence Carstensen; Thomas Crawford; Steven Hodges; Randolph Wynne; Carl Zipper;

Associate Professors: Andrew Ellis; John Galbraith; Marcella Kelly; Lisa Kennedy; Korine Kolivras; Kevin McGuire; Robert Oliver; Lynn Resler; Yang Shao; Valerie Thomas;

Assistant Professors: Timothy Baird; Zachary Easton; Luke Juran; Megan O'Rourke; Meredith Steele; Stephanie Zick;

Research Faculty: William Ford; Jeffrey Marion;

General Contact: geospatial@vt.edu

Graduate Site: <http://geography.vt.edu/GEA/index.html>

Student Handbook: <http://geography.vt.edu/GEA/index.html>

The interdisciplinary doctoral program in Geospatial and Environmental Analysis focuses on the application of geospatial analysis for improving the science, management, and conservation of natural resources and the environment. Based in the College of Natural Resources and Environment, the program draws upon the expertise of faculty from the Departments of Forest Resources and Environmental Conservation, Geography, Fisheries and Wildlife Sciences, and Wood Science and Forest Products, as well as from those in departments in other colleges, including Crop and Soil Environmental Sciences, Civil and Environmental Engineering, and Biological Systems Engineering. Geospatial research involves Geographic Information Systems (GIS), the Global Positioning System (GPS), remote sensing, and imagery analysis. Environmental analysis focuses on the complex interactions among people, nonhuman biota, and environmental conditions. This doctoral program combines cutting-edge training and research in the theory and application of geospatial science with environmental analysis to enhance research on a broad range of contemporary natural resource and environmental issues. Graduates will be prepared for careers in higher education, government, research, and industry.

SPECIAL FACILITIES

The program has a wide range of facilities necessary for advanced training in geospatial and environmental analysis, including state-of-the-art labs for GIS and for biogeography (for the study of recent and long-term environmental history and vegetation change). The Center for Environmental Applications of Remote Sensing (CEARS), housed in the College of Natural Resources and Environment, is a world-class geospatial research facility established in 1997 as a NASA center of excellence in applications of remote sensing to regional and global integrated environmental assessments. With core faculty in both the Geography and Forest Resources and Environmental Conservation departments, it is Virginia Tech's focal point for interdisciplinary research, instruction, and outreach focused on remote sensing applications. Doctoral candidates in this program will have the opportunity to interact with CEARS researchers who have extensive expertise with a wide variety of data types (including active and passive microwave, multispectral, hyperspectral, lidar, aerial photographs) and application areas (such as temperate and tropical forestry, limnology, ecological modeling, marine biology, environmental monitoring, urban ecology, carbon sequestration, tropical biodiversity assessment, phenology studies, rangeland management, invasive species, and fire fuel loading).

Facilities, Equipment, and Other Resources

Facilities, Equipment, and Other Resources Principal resources and facilities available to GEA students include those in student departments and within the College's Center for Environmental Applications of Remote Sensing (CEARS). Below are those within the Department of Geography and CEARS. Geography Department Lab: Hardware: 33 Dell Precision 3630 Processor: INTEL 6 Core I7 at 3.2 Ghz Ram: 32 GB per system Internal Storage: 1 Tb solid state GPU: NVIDIA GeForce GTX 1060 with 6 Gb VRAM Peripherals: HP Designjet T730 large format printer Relevant Software's: complete suite of image processing (ENVI, ERDAS Imagine) and associated software, including compilers (IDL, Absoft Fortran, Matlab, Visual Studio, Python), statistical packages (R, SAS), and GIS (ESRI products). College of Natural Resources and Environment, Center for Environmental Applications of Remote Sensing (CEARS) Lab: Hardware: 22 networked (1 Gbit) Precision Workstations (15 - Quad core Xeon with 64 Gb ram, 7 - Six core Xeon with 128 Gb ram) Internal Storage: 3 Tb Peripherals: HP Designjet T730 large format printer Relevant Software: complete suite of image processing (ENVI, ERDAS Imagine) and associated software, including compilers (IDL, Absoft Fortran, Matlab, Visual Studio, Python), statistical packages (R, SAS), and GIS (ESRI products). GPS equipment available: 4 Trimble GeoXT 18 Garmin Etrex Meteorological Equipment: 3 ea Campbell Scientific mobile metrological units: RM Young wind monitor, CSL Temperature/RH probe, Sentra 278 Barometer, Garmin GPS receiver, CR800-ST-SWNC Measurement & Control Datalogger Handheld Field Spectrometer: ASD PANalytical FieldSpec Handheld 2 Field Spectrometer, 325-1075nm. w/wforeoptics and Rad.Cal.

DEGREES OFFERED

PhD Degree

Offered In (Blacksburg)

TOEFL

Paper: (550.0)

Computer: (213.0)

iBT: (80.0)

GRE

General Test: Verbal (153.0), Quantitative (156.0), Analytical Writing (4.0)

Students must complete 90 credit hours and a dissertation that involves original research. The program has three areas of required coursework totaling 31 credits. The first is composed of required Core Courses consisting of 13 hours of classes that provide training in advanced research techniques, statistical and spatial analysis, and discussion of contemporary issues in GIS and remote sensing. The second area of coursework requires the selection of 12 hours of electives in geospatial classes involving both GIS and remote sensing. The third area involves 6 hours of classes from electives in environmental analysis. Students must also complete a minimum of 30 hours of Research and Dissertation

and 29 hours of other coursework and/or additional hours of Research and Dissertation. Students can transfer approved graduate coursework taken at Virginia Tech prior to enrolling in this program and up to 15 hours of coursework from another university.

NATURAL RESOURCES

Michael Mortimer, Program Director

Professors: Robert Hull; Patricia Raun;

Associate Professors: Marc Stern;

Assistant Professors: Anamaria Bukvic;

Adjunct Professors: Desiree DiMauro; Megan Draheim; James Egenrieder;

Selma Elouardighi; Heather Eves; John Hadidian; Jennifer Jones; Adam Kalkstein;

Courtney Kimmel; Jennifer Lawrence; Daniel Marcucci; Emily Talley; Paul Wagner;

Louise Wise;

Affiliated Faculty: Kieran Lindsey; Michael Mortimer; David Robertson;

MNR Info: emtalley@vt.edu

MNR Degree: <https://cligs.vt.edu/master-s-degrees.html>

Graduate Certificates: <https://cligs.vt.edu/certificates.html>

Center for Leadership in Global Sustainability: <https://cligs.vt.edu/>

Learn the skills, frameworks, and capabilities needed to address a broad range of sustainability challenges in local communities, the workplace, and throughout global society. The Master of Natural Resources (MNR) is designed for working professionals aiming to advance their careers or shift to leadership roles in the environmental and sustainability fields or functions. Delivered through two flexible programs--Executive (in-person/online hybrid) and Online--our innovative instruction allows you to immediately apply what you learn to real-world challenges. A graduate degree from a widely respected and fully accredited university like Virginia Tech can lead to new rewarding career opportunities, whether you are looking to step up or pivot. To help chart career trajectories, all our students receive personalized career coaching. Study Subject Themes: Climate Change and Resiliency Energy Systems Food and Agriculture Water and Watersheds Poverty and Development Urbanization and Sustainable Cities Global Flows and Supply Chains Biodiversity and Ecosystems Flexible Formats: Diverse undergrad majors welcomed Graduate in as few as 12 months 30-credit, non-thesis degree 10-day global Study in a developing country No GRE required A background in environmental science is not required Admission decisions are based on both academic and professional experience No additional cost for out-of-state or international students Executive program meets one weekend a month in the Washington, DC metro area Veterans benefits can be used to cover the cost of both degree program formats. Financial aid is available. Contact academic advisor Emily Talley (emtalley@vt.edu) to discuss our graduate programs.

SPECIAL FACILITIES

The Center for Leadership in Global Sustainability (CLiGS) is located near Washington, DC, at the Virginia Tech Research Center in Arlington (VTRC-A), a U.S. Green Building Council LEED-certified facility. The VTRC-A building is just one block from the Ballston Metro station and Interstate 66. It is also within walking distance of major government

organizations and association headquarters, including the National Science Foundation (NSF), Defense Advanced Research Projects Agency (DARPA), Office of Naval Research (ONR), US Fish & Wildlife Service (USFWS), and The Nature Conservancy (TNC). Get directions to the VTRC-A

DEGREES OFFERED

MNR Degree

Offered In (Virtual, National Capital Region)

TOEFL

Paper: (550.0)

iBT: (80.0)

The Master of Natural Resources (MNR) graduate degree requires 30 credit hours and is offered in Online and Executive forms. See the weblink below for details. Master of Natural Resources Graduate Certificates are offered in two formats: Natural Resources (GCNR) and Global Sustainability (GCGS). See the weblink below for details. Graduate Certificates

GRADUATE COURSES (NR)

NR 5014:

Constructing Sustainability

Synthesize ecological, economic, and solid dimensions of sustainable and resilient systems. Examine history, theory, current status, and future prospects of sustainability and resiliency as organizing principles for natural resource management professions. Situate science, policy, professional and civic institutions in sustainability efforts. Analysis sustainable and resilient bio-cultural systems. Pre-requisite: Graduate Standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

NR 5024:

Sustainability Case Studies

Theory, properties, methods, and writing of case studies useful to sustainability professionals. Application of case study to explain and help guide management and planning of natural resource systems, such as water, food and agriculture, climate, and energy. Generalize from specific cases to global situations. Pre: Graduate standing; restricted to Virtual Campus students.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

NR 5044:

Environmental Conservation and the American Landscape

Comprehensive examination of American attitudes toward the environment and the history of efforts to protect it, from early European settlers to conservationists of today. History of the U.S. Forest Service and the National Park Service, as well as other federal and private land and resource conservation entities. Concept of wilderness, particularly within national parks and forests. Definitions of the American environment in the context of national development and our evolving strategies of environmental conservation. Primarily taught at National Capital Region. Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

NR 5114:

Global Issues in Environmental Sustainability

Competencies sustainability professionals need to address global sustainability challenges and pursue sustainability careers globally. Situate specific country challenges in larger global trends. Investigate specific sustainability situations outside the US, including goals, strategies, and stakeholders. International travel experience; cultural competencies. Team/collaborative project management. May be repeated 2 times, visiting different countries and different content, for a maximum of nine credit hours. Pre: Graduate standing; restricted to Virtual Campus students.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

NR 5174:

Sustainability Systems

Systems thinking needed by sustainability professionals. Basic competencies, language, and confidence needed to engage with other experts in collaborative problem-solving processes of pressing global

sustainability challenges. Focus on sustainability systems represented in the United Nations Sustainable Development Goals: water, climate, agriculture, energy, poverty, urbanization, global material flows, biodiversity. System properties and other leverage points for influencing change. Collaborative problem-solving skills needed to work on multidisciplinary teams. Double loop learning and reframing problems and questions. Pre: Graduate standing; restricted to Virtual Campus students.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Online Lecture

Instruction Type(s): Online Lecture

Prerequisite(s):

Corequisite(s):

NR 5184:

Adaptive Management

Conservation strategies and tools needed by sustainability professionals. Concept mapping, threat assessment, socio-cultural context evaluation, biodiversity threat-mitigation strategies, monitoring, evaluation for natural resource conservation. Professional skills for working in conservation organizations (i.e., writing, team work, budgeting, management planning, personnel estimates). Pre: Graduate standing; restricted to Virtual Campus students.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

NR 5194:

Environmental Ethics

In depth analysis of current and past environmental issues in context of ethical and philosophical considerations starting from individual and group ethics and moving toward global and societal ethics. Addresses the interaction between influences and pressures such as social justice, cultural traditions, politics, science, technology, and religion and environmental ethics. Explores practical application of professional ethics to the resource decision-making process regarding current environmental issues. Graduate standing required, and National Capital Region students only.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

NR 5204:

Water Conflict & Management

Freshwater conflict issues and management for environmental sustainability professionals. Amount, quality, and distribution of freshwater in the US and globally. Major US and global water management agencies and programs. Impacts of local needs, cultures, and laws on water conflict. Case studies of water management and water conflicts in US and globally. Water conflict management. Water refugees. Pre: Graduate standing; restricted to online Virtual Campus students.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Online Lecture

Instruction Type(s): Online Lecture

Prerequisite(s):

Corequisite(s):

NR 5214:

Urban Water Systems

Urban water systems and planning challenges for sustainability professionals. Case studies of contemporary urban water problems and solutions from North America and globally. Water, hydrology, green infrastructure, and rapid urbanization. Water and emergency management. Connection of urban water system to the regional landscape. Pre: Graduate standing; restricted to Virtual Campus students.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Online Lecture

Instruction Type(s): Online Lecture

Prerequisite(s):

Corequisite(s):

NR 5264:

Watershed Stewardship

Watershed stewardship theory and practices for sustainability professionals. Identification, mapping, evaluation of peri-urban and rural watershed characteristics. Watershed threat assessment and restoration planning. Stewardship programming promoting water quality monitoring, public education, and advocacy. Pre: Graduate standing; restricted to Virtual Campus students.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

NR 5274:

Infrastructure for Resilience

Infrastructure design and development for urban sustainability and resilience. Focus on the interface of engineered, natural, and urban systems relevant to practicing sustainability professionals. Contemporary case studies illustrating innovations, processes, stakeholders, policies, and challenges of infrastructure planning for resiliency. Foundation for interdisciplinary team work on infrastructure planning. Pre: Graduate standing; restricted to Virtual Campus students.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

NR 5284:

Coastal & Marine Management

Science, management, planning, and policy for sustainability professionals working in coastal and marine environments. Social, economic, and environmental interactions that cause coastal and marine system problems. National and international policy. Coastal zone management strategies and marine spatial planning. Pre: Graduate standing; restricted to Virtual Campus students.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Online Lecture

Instruction Type(s): Online Lecture

Prerequisite(s):

Corequisite(s):

NR 5344:

International Environmental Law & Policy

Purpose, scope, and justification of international environmental law and policy. Sources of international laws and conventions and their respective strengths and weaknesses; assessment and enhancement of their effectiveness. Mechanisms to assess and facilitate implementation and compliance. Non-environmental actors and regimes. Pre: Graduate standing; restricted to Virtual Campus students.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

NR 5394:

Transboundary Resource Management

Cultural, social, geographic, and political dimensions of transboundary management for sustainability professionals. Types of boundaries.

Natural resources boundary management needs and challenges when managing resources across boundaries. Strategies and best practices for transboundary resource management. Pre: Graduate standing; restricted to Virtual Campus students.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

NR 5424:

Urban Wildlife

Provides a topical and historical overview of the field of urban wildlife and issues encompassed by wildlife in cities and towns. Focus will be on the structure and nature of cities as ecosystems. The role of wildlife within urban ecosystems and the relationships of people to wild animals will be explored. Graduate standing required. National Capital Region students only.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

NR 5434:

Human-Wildlife Conflicts

Resolving human-wildlife conflicts in urbanizing environments. Legal and regulatory policy tools. Social science theory and facilitation tools for cooperation, collaboration, innovation, and conflict resolution applied to human-wildlife interactions. Social and ecological benefits and costs of managing conflicts. Human-wildlife ethics. Pre: Graduate standing; restricted to Virtual Campus students.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Online Lecture

Instruction Type(s): Online Lecture

Prerequisite(s):

Corequisite(s):

NR 5454:

Biodiversity Stewardship

Biodiversity science useful to sustainability professionals stewarding community conservation efforts. Mapping and documenting biodiversity; setting biodiversity goals; challenges of climate change, water use, habitat loss, and invasive species. Roles of government agencies, advocacy groups, and businesses in biodiversity stewardship.

Biodiversity partnerships. Generating support for stewardship with community awareness and citizen science. Pre: Graduate standing; restricted to Virtual Campus students.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Online Lecture

Instruction Type(s): Online Lecture

Prerequisite(s):

Corequisite(s):

NR 5464:

Biodiversity Policy

Biodiversity policy tools for practicing sustainability professionals.

International conventions and US laws protecting biological diversity, threatened and endangered species, and habitats. Tools and approaches for monitoring and assessing convention effectiveness.

Policy obstacles and adaptive management responses. Pre: Graduate standing; restricted to Virtual Campus students.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

NR 5534:

Climate Change Policy

Policy tools needed by sustainability professionals to address climate change. US and International policies and efforts to address climate issues. Business policies for adaptation and mitigation. Climate justice. Local government policy tools for mitigation, adaptation, sequestration. Climate geoengineering. Pre: Graduate standing; restricted to Virtual Campus students.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

NR 5544:**Climate Adaptation**

Competencies needed by sustainability professionals to assist climate change adaptation efforts. Impacts of climate change. Climate vulnerability assessment of communities, environments, and businesses. Adaptive capacity and planning for resilience. Scenario planning at local and national scales and in developed and developing countries. Risk management. Communication, process, and politics of implementation. Limits of adaptation. Pre: Graduate standing; restricted to Virtual Campus students.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

NR 5634:**Urban Ecology**

Theory and practice of urban ecology. The science and policy of urban ecosystems. Local, regional, and global aspects of urban ecological processes. Social, historical, and political dimensions of urban ecosystem management and environmental governance. Strategies for sustainable urban development. Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

NR 5684:**Foundations of Federal Land Management**

Provides the framework for public land laws and policies development. Reviews the origins and status of significant laws and policies affecting federal land management, including the evolution to present and impacts. Emphasis is placed on legal concepts, critical analysis, and problem solving. Includes student interactions with land management agencies and with professional organizations. Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

NR 5714:**Ecosystem Management**

Problem-based learning format to explore the application of ecological, economic, social, and management principles to natural resource management. Examines the changes in social values, technologies and demographics driving the ecosystem management model. Contrasts how the major federal agencies and other organizations implement ecosystem management. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

NR 5724:**Conservation Ecology**

Explores the interdisciplinary knowledge, theories, and research related to natural resource management and conservation. Emphasis will be on the synthesis and integration of knowledge, skills and abilities required to develop innovative approaches to sustain resource development as conservation issues become more complex. Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

NR 5814:**Business Sustainability Applications**

Business and corporate sustainability theory and best practices for environmental sustainability professionals. Business motivations for sustainability. Corporate Social Responsibility and sustainability programs and practices. Markets and demand for green goods and sustainable brands. Global trends in markets and demographics. Supply chain management for climate and other sustainability challenges. Sustainable dimensions of investing, reporting, employee recruitment and retention, insurance, and risk management. Circular economy policy and theory. Pre: Graduate standing; restricted to Virtual Campus students.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

NR 5824:**Sustainability Accounting and Reporting**

Accounting, evaluation, compliance, and reporting practices needed by sustainability professionals. Governance by disclosure through accountability and transparency. Applications include greenhouse gas, water, and human rights. Labels, certification, standards, and roundtables. Emphasis on reporting for businesses and government organizations. International and sectoral differences in sustainability reporting platforms and practices. Pre: Graduate standing; restricted to Virtual Campus students.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Online Lecture

Instruction Type(s): Online Lecture

Prerequisite(s):

Corequisite(s):

NR 5844:**Leadership for Sustainability**

Leadership tools needed by practicing sustainability professionals. Leadership theory for wicked situations facilitating direction, alignment, commitment. Leadership practices at four levels of social organization: individual, team, organization, network. Individual level tools include self-awareness of personality traits, conflict and influence style, integrity, trust. Team tools include principles, feedback, project management, active listening. Organization tools include strategic planning, indicators, organizational change. Network level tools include boundary spanning, cross-sector collaboration, partnering. Pre: Graduate standing; restricted to Virtual Campus students.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

NR 5854:**Leadership Communication for Sustainability Professionals**

Persuasive communication and communication for collaboration within teams and within and across organizations focused on sustainability topics. Influence skills such as emotional intelligence, self-awareness, empathy, active listening, influence without authority. Professional communication best practices, including framing and presentation skills. Personalized plan to develop communication competencies. Pre: Graduate standing; restricted to Virtual Campus students.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

NR 5864:**Sustainability Science**

Roles and limits of natural resources and the environment in relation to human, political, social, and economic goals and aspirations. Holistic and systemic focus on core questions of sustainability science including: examining interactions between human and natural systems; evaluating emerging models and conceptualizations of Earth-society sustainability; assessing impacts of long-term trends in nature-society interactions; determining limits of resilience and sources of vulnerability for such interactive systems; developing incentive structures for guiding society toward more sustainable trajectories for interacting with the Earth; and harnessing science and technology to address sustainability goals. Graduate standing required. National Capital Region students only.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

NR 5874:**Strategies for Sustainability**

Strategies to influence sustainability outcomes. Focus on social science approaches to influencing and explaining human behavior. Applied projects focused on interventions to address sustainability challenges. Pre: Graduate standing; restricted to Virtual Campus students.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Online Lecture

Instruction Type(s): Online Lecture

Prerequisite(s):

Corequisite(s):

NR 5884:**Topics in Natural Resources**

Advanced exploration of topical studies related to natural resources science, policy, and management. Topics and formats will vary, and course may be taken for credit more than once up to a total of 6 credits. Graduate standing required. National Capital Region students only.

Credit Hour(s): 1 TO 3

167 Lecture Hour(s): 1 TO 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

NR 5904:

Project and Report

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research, Online Research

Instruction Type(s): Research, Online Research

Prerequisite(s):

Corequisite(s):

NR 5954:

Study Abroad

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

NR 5964:

Field Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

NR 5974:

Independent Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Independent Study, VI

Instruction Type(s): Independent Study, VI

Prerequisite(s):

Corequisite(s):

NR 5984:

Special Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

NR 5994:

Research and Thesis

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research

Instruction Type(s): Research

Prerequisite(s):

Corequisite(s):

NR 6104:

Advanced Topics in Remote Sensing

In-depth coverage of advanced topics in the field of remote sensing selected to cover emerging techniques and technologies. Examples of topics, which will differ each semester, include field data in support of remote sensing, accuracy assessment, and hyperspectral remote sensing. Critical assessment of the ways in which remotely sensed data and information are employed in varied scientific disciplines and by society.

Credit Hour(s): 0 OR 3

Lecture Hour(s): 0 OR 2

Instruction Type(s): Lab, Lecture, Online Lecture

Instruction Type(s): Lab, Lecture, Online Lecture

Prerequisite(s): GEOG 4354 OR GEOS 4354, (FOR 5254 OR FREC 5254), GEOG 5104 OR (FOR 5104 OR FREC 5104)

Corequisite(s):

**ALLIANCE FOR SOCIAL, POLITICAL, ETHICAL,
AND CULTURAL THOUGHT**

Francois Debrix, Program Director

Emeriti Faculty: Elizabeth Fine; Richard Rich; Richard Shingles; Robert Siegle;

Professors: Francois Debrix; Brett Shadle;

Associate Professors: Danna Agmon; Bettina Koch; Michael Moehler; Rachel Scott;

Assistant Professors: Mauro Caraccioli; Bikrum Gill; Desiree Poets; Audrey

Reeves; Balbir Singh;

Affiliated Faculty: Onwubiko Agozino; Aaron Ansell; Clair Apodaca; Paul Avey; Andrea Baldwin; Mark Barrow; France Belanger; Shannon Bell; Binio Binev; Cermetrius Bohannon; Aaron Brantly; Daniel Breslau; Brian Britt; Letisha Brown; David Brunsma; Danille Christensen; Carolyn Commer; Nicholas Copeland; Cara Daggett; Giselle Datz; Priya Dixit; Arthur Ekirch; Edward Ewing; Jessica Folkart; Matthew Gabriele; Thomas Gardner; James Garrison; Edward Gitre; Carmen Gitre; Nicholas Goedert; Heather Gumbert; Saul Halfon; Anthony Harrison; Matthew Heaton; Ashley Heflin; Rebecca Hester; Karen Hult; Benjamin Jantzen; Eric Jardine; Caitlin Jewitt; Sharon Johnson; Sylvester Johnson; Melanie Kiechle; Karin Kitchens; James Klagge; Karen Kovaka; Christine Labuski; Robert Leonard; Douglas Lind; Ilja Luciak; Timothy Luke; Allan Lumba; Jordan MacKenzie; Marian Mollin; Wayne Moore; Amy Nelson; Scott Nelson; Zhange Ni; Shaily Patel; Lydia Patton; Joseph Pitt; Paulo Polanah; Katrina Powell; Karl Precoda; Anita Puckett; Besnik Pula; Patrick Roberts; John Ryan; Michael Saffle; Emily Satterwhite; Andrew Scerri; Peter Schmitthener; Helen Schneider; Paula Seniors; Robert Stephens; Max Stephenson; Ioannis Stivachtis; Jessica Taylor; Gresilda Tilley-Lubbs; Gerard Toal; Sharone Tomer; Kelly Trogon; Vinodh Venkatesh; Peter Wallenstein; Ronda Watson; Edward Weisband; Laura Zanotti;

General Contact: aspect@vt.edu

Student Handbook: <http://liberalarts.vt.edu/departments-and-schools/alliance-for-social-political-ethical-and-cultural-thought.html>

The Ph.D. in Social, Political, Ethical and Cultural Thought (ASPECT) prepares graduate students to undertake theory-based, problem-centered, and interdisciplinary analysis informed by social, political, ethical and cultural thought. ASPECT is designed to interest those seeking a program of study with a framework wider than that of a specialized traditional disciplinary department. The program is unique in offering a curriculum that fosters research and teaching that communicates theory across the limits that frequently divide between units in the social sciences, humanities, and professional schools. The program promises to place in tandem bodies of thought and their research applications that have frequently cast divisions along fault line of political theory vs. cultural studies, social theory vs. ethical thought, etc. It is the modest ambition of the ASPECT curriculum, by contrast, to foster a research and teaching program that enables Ph.D. students to pursue appropriate course work and research commensurate with the complexities of the issues they aim to investigate. The curriculum stresses flexibility and originality. It permits a focus on overarching questions by offering training in areas of concentration as well as education in interdisciplinary ways of knowing. Each area of concentration, in turn, is composed of a cluster of multidisciplinary offerings. Students will be prepared to teach introductory and required courses in particular disciplines through their graduate teaching assistantships. However, their Ph.D research will address questions that span a number of different approaches and fields in a truly interdisciplinary manner. The ASPECT Ph.D. curriculum is supported both by some seventy faculty affiliates (see:

<http://liberalarts.vt.edu/departments-and-schools/alliance-for-social-political-ethical-and-cultural-thought.html>) with tenure homes in twelve campus departments and three colleges: the College of Architecture and Urban Studies, the College of Business and the College of Liberal Arts and Human Sciences, including the four core departments of

History, Philosophy, Political Science, and Religion and Culture.

SPECIAL FACILITIES

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DEGREES OFFERED

PhD Degree

Offered In (Blacksburg)

TOEFL

Paper: (550.0)

Computer: (213.0)

iBT: (80.0)

GRE

The ASPECT doctoral program at Virginia Tech is for students who have previously earned an M.A. or equivalent (e.g. JD, MBA, MS) before pursuing doctoral study. Under the assumption that students accepted into the ASPECT program with a Masters degree or equivalent either from Virginia Tech or elsewhere have received credit for 30 credit hours, they then will undertake a minimum of 60 semester hours of further study, leading to the defense of a Ph.D. The Ph.D. curriculum concentrates on interdisciplinary methodological and theoretical issues. Therefore, ASPECT is where social, political, ethical, and cultural thought are put to work in understanding social and individual transformations in contemporary and historical contexts. Course requirements for the Ph.D. can ordinarily be completed during two years of residency and entail successful completion of 42 credit hours, leading to the defense of a Ph.D. dissertation proposal and preliminary exams during the fourth semester. Thereafter, dissertation research will be undertaken under the supervision of a multidisciplinary advisory committee and remaining credits may be earned either by taking additional classroom courses or research and dissertation credits. Students pursuing the ASPECT Ph.D. select a major and a minor concentration chosen from among four areas: 1) social thought, 2) political thought, 3) ethical thought, and 4) cultural thought. Additional ASPECT courses requirements offer education in interdisciplinary theory, methodology, and professional development. The ASPECT curriculum consists of four kinds of classroom courses: 1) All candidates will take 12 credit hours of core ASPT courses (ASPT 6004, ASPT 6104, ASPT 6204, and ASPT 6904); 2) 21 credit hours selected from ASPECT cross listed departmental offerings (six of the latter are brand new courses expressly designed to support program goals), 3) six credit hours in social science or humanistic research methods; and, 4) three credit hours in pedagogical practices (GRAD 5114). All students are required to identify a major and minor field (one each selected from the four concentration areas). The 21 credit hours mentioned in (2), are selected to fulfill the major and the minor areas of concentration, with 12 credit hours in the major and 9 credit hours in the minor area. No more than 9 credit hours can be taken in one department in fulfillment of the major area, no more than 6 from one department in the minor area.

GRADUATE COURSES (ASPT)

ASPT 5114:

Critical Research Design

Analysis of challenges related to power and ethics in the design of political research. Special emphasis on research question formulation, case selection, identification of sources, and qualitative research methods. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ASPT 5124:

Rel and Modernity in the West

A study of the relationship between religion and modernity in the West, with analysis of whether modern society is disenchanted or secularized, or whether religion has remained a potent force in western society and thought. Through a survey of some of the major thinkers and themes of modern religious thought, we will consider the philosophical, economic, political, and legal aspects of the location of religion in the modern world.

Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ASPT 5134 (RLCL 5134):

Islamic Political Thought

The course will review the most significant elements of Islamic political thought throughout Islamic history: the teaching of the Quran, the formation of political thought in the medieval period, and the main trends of political thought in the modern world, including in the West. It will examine the connection between Islamic political thought in the medieval and modern periods. Graduate standing requires.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ASPT 5214 (HIST 5214):

Topics in Global History

A variable content course exploring historiographical approaches to the study of global history from the classical age to the present. Special emphasis on chronological frameworks, histories and theories of

globalization, and implications of new scholarship in global history for research and teaching. May be taken with different content for a total of 6 credit hours. Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ASPT 5414 (HIST 5414):

Topics in Cultural History and Theory

A variable content course exploring the intersection of cultural theory and the discipline of history. Introduces important theoretical contributions to the study of culture and examines how historians have used these constructs to interpret the past. May be taken with different content for a total of 6 credit hours. Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ASPT 5464 (PSCI 5464):

Critical Security Studies

Provides an overview of the critical study of security in world politics. Introduces alternative conceptualizations of security to the military-focused, state-centric security/strategic studies. Considers constructivist, post-structuralist and critical theoretic attempts to conceptualize the nature of security. Compares and contrasts these approaches with widely-accepted understandings of security in light of key debates in contemporary security studies.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): PSCI 5444 OR PSCI 5444 (UG)

Corequisite(s):

ASPT 5974:

Independent Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Independent Study

170 Instruction Type(s): Independent Study

Prerequisite(s):

Corequisite(s):

ASPT 5984:

Special Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ASPT 5994:

Research and Thesis

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research, Online Research

Instruction Type(s): Research, Online Research

Prerequisite(s):

Corequisite(s):

ASPT 6004:

Topics Interdisciplinary Perspectives in Soc, Pol, Ethical, & Cultural Thought

Topical seminar devoted to a significant problem in social, political, ethical and cultural thought. Integrates readings reflective of those four domains and is taught by an interdisciplinary team with research expertise in the particular problem addressed by the course. Via their substantive focus and advanced theory orientation, the seminar topics also offer comparative exposure to the ontologies and epistemologies embedded in disciplinary frameworks. Linked to a speaker series integrated with the course. May be repeated for a maximum of 9 credit hours. Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ASPT 6014:

Theories of Globalization

Examination of past and present eras of globalization through various theoretical perspectives. Addresses colonialism and emergence of western models for development of poor countries. Controversies about

impacts of current globalization on the nation-state, cultures, ecosystems, and racial/ethnic/gender inequalities. Explores present trends, such as globalization of agriculture and food systems, industrial production, migration, human rights, and anti-globalization resistance.

Prerequisite may be substituted for any equivalent 5000 level international course.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): GIA 5264 OR UAP 5264

Corequisite(s):

ASPT 6024 (RLCL 6024):

Contemporary Religious Thought

Concentrates on a selected major figure in religious thought in relation to contemporary society, politics, ethics, and culture. May be repeated up to five times with different content. Pre-requisite: Graduate Standing required

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ASPT 6104:

Interdisciplinary Perspectives in Methodology

Addresses problems of methodology that face researchers pursuing theoretically informed interdisciplinary research involving words, objects, and images. Provides exposure to disciplinary based and interdisciplinary methodologies. Emphasis on the methodological complexities of working in tandem with varied objects of analysis in theoretical and practical terms. Graduate standing and prior completion of an approved disciplinary based methodology course required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ASPT 6204:

Topics of Indisciplinary Frameworks in Soc, Pol, Cultural & Ethical Thought

Topical seminar devoted to a significant problem in social, political, ethical and cultural thought. Integrates readings reflective of at least two

of the four bodies of thought and theory addressed by ASPECT. Offers problem-centered, advanced exposure to interdisciplinary work. Team taught by two instructors with research expertise in the particular topic. May be repeated for a maximum of 9 credit hours. Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

ASPT 6224:

Distributive Justice

Influential contemporary theories of distributive justice. Social, political, ethical, and cultural dimensions of distributive questions. Utilitarianism, liberalism, libertarianism, pluralism, multiculturalism, autonomy, rights, needs, (global) egalitarianism, and (global) poverty. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ASPT 6904:

ASPECT Professional Development

Preparation for successful completion of the interdisciplinary Ph.D. and for post-doctoral professional roles. Assists Ph.D. students in proposal preparation, identifying funding ASPECT related research, determining publication outlets and manuscript preparation requirements, and conference paper guidelines and presentation. Graduate standing in ASPECT doctoral program required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ASPT 6984:

Special Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ASPT 7994:

Research and Dissertation

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research, Online Research

Instruction Type(s): Research, Online Research

Prerequisite(s):

Corequisite(s):

COMMUNICATION

Robert Denton, Program Director

Emeriti Faculty: Edward Sewell;

Professors: Robert Denton; Carlos Evia Puerto; William Hopkins; James Ivory; Jim Kuypers; John Tedesco;

Associate Professors: Rachel Holloway; Michael Horning; Adrienne Ivory; Nneka Logan; Jennifer Mackay; Marcus Myers; Brandi Watkins;

Assistant Professors: Megan Duncan; Natalia Mielczarek; Stephanie Smith; Chelsea Woods;

W. Thomas Rice Chair: Robert Denton;

Professor of Practice: Douglas Cannon;

Graduate Contact: comm@vt.edu

School of Communication: <https://liberalarts.vt.edu/departments-and-schools/department-of-communication/academic-programs/master-of-arts-in-communication.html>

Graduate Facebook: <https://www.facebook.com/commvtgrad/>

Program introduction The M.A. in Communication degree program offers two majors: (1) Communication, a research-driven curriculum offering courses in two areas: strategic communication and media, technology, and society, and (2) Reputation Management, a professionally focused curriculum designed to prepare public relations practitioners with five or more years of experience for broader management responsibilities in strategic corporate communication. The Communication major prepares graduates to pursue communication doctoral studies, research positions in industry, and advanced teaching or professional careers. The major blends social-scientific and humanistic research with communication theory in the areas of media, technology, and society. Students are introduced to diverse theoretical and methodological perspectives, with a focus on research in every class. Faculty strengths in digital, political, strategic, rhetorical, and organizational communication enrich student learning and career readiness. The Reputation Management major prepares graduates for advanced communication management positions

in corporations, nonprofit organizations, and government agencies. The major combines coursework in communication, public relations, and business. Students work with public relations and business scholars to develop theory-based reputation-management initiatives to solve business problems, advance strategic organizational outcomes, improve perceptions of organizations with key constituencies, and enhance goodwill assets and corporate market value. Degree Requirements All graduate students receiving the M.A. in Communication degree must complete 36 credit hours. Required coursework for students in the Communication major includes 9 credit hours of core subjects (Communication Theory, Quantitative Research in Communication, and Qualitative Research in Communication), 15 credit hours of major-specific coursework, at least 6 credits hours of electives, and 6 hours of thesis credit. The thesis includes an oral defense administered by the student's advisory committee and a public presentation of thesis findings. Coursework for the Reputation Management major requires the same 9 credit hours of core subjects, 15 credit hours in specified public relations courses, 9 credit hours of electives in suggested business courses, and 3 hours in professional project or report (non-thesis) credit. Successful completion of the M.A. program's ethics requirement is part of the progress toward degree. Graduate students are encouraged to present their research at local, regional, or national professional conferences. Additional Information Students in the Communication major engage in reviewing and discussing communication research, collecting and interpreting original data, and synthesizing and presenting communication knowledge to educate others. Degree completion includes a thesis, where students research an area/question of communication interest in depth, using either a qualitative or a quantitative methodology. If you aspire to achieve a Ph.D., a thesis hones research skills in a focused area of interest. If your goal is a professional career, a thesis promotes your ability to conceptualize and to complete a research project from start to finish. We strongly encourage graduate students to attend regional and national conferences to present their work. Full and partial funding opportunities for conference travel are available. Students in the Reputation Management major apply communication and public relations theories to business problems in real-world situations. These students, public relations practitioners with five or more years of experience, complete professional projects or reports. These allow students to demonstrate that they can put what they have learned in coursework into practice in a variety of business contexts. The program boasts a nearly 100% placement rate for Communication majors at top Ph.D. departments for graduates interested in pursuing doctoral study. Those planning a professional career typically are employed within four months of graduation. Communication M.A. students are active researchers, provide university and community service through the Communication Graduate Students Association (CGSA), and establish a Hokie community of friends and colleagues. For Fall admission and consideration for graduate funding (serving as a departmental graduate teaching assistant), the electronic application must be completed by January 13, 2021. First round decisions are made early in February. Second-round applications (which do not include funding requests) are accepted until April 15, 2021, with decisions occurring soon thereafter. The program does not typically accept spring admissions for full-time students; part time students should consult with the graduate director. Detailed information about the program's goals, funding opportunities, faculty, and application procedure, may be found by visiting the Communication M.A. webpage.

SPECIAL FACILITIES

The School of Communication's research facilities include a range of spaces and equipment to facilitate social and behavioral research

employing multiple methods.

The Digital Media Research Facility

The Digital Media Research Facility is housed in the basement of Shanks Hall and includes multiple research laboratory facilities, including the Virginia Tech Gaming and Media Effects Research Laboratory (VT G.A.M.E.R. Lab) and other laboratories in development. Research equipment contained in the labs includes psychophysiological measurement equipment, Perception Analyzer real-time-response equipment, digital gaming and virtual reality hardware, and software for media production, data analysis, and data visualization. Spaces include multi-purpose rooms, laboratory experiment rooms, and an observation room with a one-way mirror.

DEGREES OFFERED

MA Degree

Offered In (Blacksburg, National Capital Region)

TOEFL

GRE

General: Verbal (150.0), Quantitative (152.0), Analytical (4.0)

The M.A. in Communication degree program offers two majors: (1) Communication, a research-driven curriculum offering courses in two areas: strategic communication and media, technology, and society, and (2) Reputation Management, a professionally focused curriculum designed to prepare public relations practitioners with five or more years of experience for broader management responsibilities in strategic corporate communication. Degree Requirements: All graduate students receiving the M.A. in Communication degree must complete 36 credit hours. Required coursework for students in the Communication major includes 9 credit hours of core subjects (Communication Theory, Quantitative Research in Communication, and Qualitative Research in Communication), 15 credit hours of major-specific coursework, at least 6 credits hours of electives, and 6 hours of thesis credit. The thesis includes an oral defense administered by the student's advisory committee and a public presentation of thesis findings. Coursework for the Reputation Management major requires the same 9 credit hours of core subjects, 15 credit hours in specified public relations courses, 9 credit hours of electives in suggested business courses, and 3 hours in professional project or report (non-thesis) credit. Successful completion of the M.A. program's ethics requirement is part of the progress toward degree. Graduate students are encouraged to present their research at local, regional, or national professional conferences.

GRADUATE COURSES (COMM)

COMM 5014:

Communication Theory

A broad survey of contemporary theories and processes of interpersonal, public, and mediated human communication. Pre:

Graduate standing

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s): COMM 5024

COMM 5024:

Quantitative Methods in Communication

Theoretical traditions and assumptions of quantitative inquiry in the communication discipline. Hypothesis generation; research design, data collection and analysis. Ethical issues, style conventions, and standards for establishing reliability and validity. Open science practices. Distinctive contributions of quantitative research to communication theory and practice. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s): null null

COMM 5034:

Teaching Practicum

Training in teaching the basic communication course at the university level. Emphasis on the theory and practice of teaching public speaking, prepared related materials and class sessions, and responding to student assignments. Graduate standing requires. May be repeated for up to 3 hours.

Credit Hour(s): 1 TO 2

Lecture Hour(s): 1 TO 2

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

COMM 5044:

Prospectus Practicum

Applied, advanced work in prospectus development.

Credit Hour(s): 1

Lecture Hour(s): 1

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): COMM 5024

Corequisite(s):

COMM 5054:

Qualitative Methods in Communication

Theoretical traditions and assumptions of qualitative inquiry in the communication discipline. Methods of data collection, interpretation, analysis, and presentation. Ethical issues, style conventions, and standards for establishing interpretive reliability and validity. Distinctive contributions of qualitative research to communication theory and practice. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

COMM 5894:

Final Examination

For non-thesis candidates who are required to register for their final examination and have completed their program of study. Not to be included in minimum 36 hours required for degree.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

COMM 5904:

Project and Report

For students pursuing a non-thesis degree. Projects may involve guided research/scholarship or an internship.

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research

Instruction Type(s): Research

Prerequisite(s):

Corequisite(s):

COMM 5974:

Independent Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Independent Study

Instruction Type(s): Independent Study

Prerequisite(s):

Corequisite(s):

COMM 5984:**Special Study**

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

COMM 5994:**Research and Thesis**

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research

Instruction Type(s): Research

Prerequisite(s):

Corequisite(s):

CREATIVE WRITING

Rebecca Weaver-Hightower, Chair

Professors: Edward Falco; Nikki Giovanni; Robert Hicok; Erika Meitner; Lucinda Roy; Carmen Smith;**Associate Professors:** Jeffrey Mann; James Vollmer;**Assistant Professors:** Evan Lavender-Smith;**Affiliated Faculty:** Gyorgyi Voros;**University Distinguished Professor:** Nikki Giovanni;**Alumni Distinguished Professor:** Lucinda Roy;**Graduate Contact:** sashupe@vt.edu**Graduate Contact:** carmens@vt.edu**Graduate Site:** <https://liberalarts.vt.edu/academics/graduate-programs/master-of-fine-arts-in-creative-writing.html>

The goal of MFA in Creative Writing is to immerse graduate students in a culture of productive creativity by doing the following: providing them with an opportunity to work in apprenticeship fashion with writing faculty; helping them to acquire a keen sense of the evolving landscape and the challenges in the field of creative writing; empowering them to create a dynamic learning community of writers in the heart of Southwest Virginia; and enabling them to develop the requisite skills they need in order to publish full-length collections of poetry and fiction. The program will also prepare students for teaching at the college-level.

SPECIAL FACILITIES

The Creative Writing program is located on the second, third and fourth floors of Shanks Hall.

Shanks Hall

The MFA program in Creative Writing is housed in the second, third and fourth floors of Shanks Hall. The main office for the English Department is 323 Shanks Hall. The Graduate Programs Coordinator, Sally Shupe, is located in 323A Shanks Hall. The office of the MFA Program Director, Carmen Gimenez Smith, is in 201 Shanks Hall.

DEGREES OFFERED**MFA Degree***Offered In (Blacksburg)*

TOEFL

Paper: (620.0)*iBT:* (90.0)*IELTS:* (8.0)

The MFA in Creative Writing is designed to be completed in three years. Students may specialize in Fiction or Poetry. A minimum of 49 hours is required for this terminal degree. A series of creative writing workshops, courses in form and theory, new media writing, composition pedagogy, and literature and theory electives are designed for students wishing to pursue careers as writers or writer/scholars at the college level. Students also have the opportunity to work as editors on the Minnesota Review and The New River: a Journal of Digital Writing and Art. A creative thesis, a written final exam, and an oral defense are required. The 49 hours required for the degree must be distributed as follows: Creative Writing Workshops: 15 hours (6704/Fiction, 6714/Poetry, 6724/Playwriting, 6734/Creative Nonfiction, 6744/New Media Writing); at least 9 hours must be in the designated specialty; students are encouraged to explore other genres in 6 hours of workshops. Form and Theory Courses: 6 hours (5734/Form and Theory of Fiction, 5744/Form and Theory of Poetry). GTA Training and Composition Pedagogy: 3 hours. Creative Writing Pedagogy and Practicum: 3 hours. Graduate School GTA Training: 1 hour. Editing a Literary Journal (5774): 6 hours. Graduate English courses: 9 hours; students may use an independent study in Editing a Digital Journal to help fulfill this requirement. Research & Thesis (5994): 6 hours; a book-length creative thesis (a collection of poetry; a collection of short stories, or a novel)

EDUCATION, CAREER AND TECHNICAL EDUCATION

Joseph Mukuni, Program Director

Emeriti Faculty: Daisy Cartwright; Konrad Eschenmann;**Professors:** H Sutphin;**Associate Professors:** William Price;**Assistant Professors:** Joseph Mukuni;**Affiliated Faculty:** Thomas Broyles; Rickie Rudd; Donna Westfall-Rudd;

iBT: (80.0)

General Contact: mjoseph7@vt.edu

Graduate Site: <http://www.soe.vt.edu/cte/index.html>

Program Director: Joseph Mukuni, (540-231-0919) Website: <https://liberalarts.vt.edu/departments-and-schools/school-of-education/academic-programs/career-and-technical-education.html> The program is designed to prepare individuals for careers in Career and Technical Education and to enhance the professional development of current career and technical educators. The CTE program offers a Master of Science degree (M.S.), an Education Specialist degree (Ed.S.) and students can earn a doctoral degree in Education Curriculum and Instruction (EDCI) with a focus on CTE. There are two concentrations in the M.S. degree program: teacher licensure and professional development for practicing educators. The teacher licensure concentration includes all the requirements for earning the master's degree and all the Virginia Department of Education requirements for earning a license to teach in one or more of the CTE program areas: Agricultural Education Business and Information Technology Education Family and Consumer Sciences Education Marketing Education The professional development for practicing educator's concentration provides professional development for individuals in one or more of the following CTE program areas: Agricultural Education Business and Information Technology Education Family and Consumer Sciences Education Health and Medical Sciences Marketing Education Trade and Industrial Education Technology Education The doctoral program in Curriculum and Instruction is primarily for individuals wishing to pursue a CTE teacher education position at a college or university or for individuals. The Ed.S. degree is appropriate for individuals who seek careers in CTE programs at the local or state level and who already hold a master's degree. In addition to the degree options, the Virginia Tech CTE program also provides online professional studies courses for provisionally licensed CTE teachers. Courses taken in this program can also be used toward earning the M.S. degree.

SPECIAL FACILITIES

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DEGREES OFFERED

MSED Degree

Offered In (Blacksburg)

TOEFL

iBT: (90.0)

The requirements for the different master's degree concentrations vary and also depend on the student's background and goals. Please see the CTE program web site and consult an advisor for specific information. Additional testing for licensure include Praxis 1, VCLA, and an industry certification exam.

EdS Degree

Offered In (Blacksburg)

TOEFL

Paper: (550.0)

Computer: (213.0)

The Ed.S. degree requires a minimum of 60 credits beyond the bachelor's degree or 30 credits beyond the master's. Please see the CTE program web site and consult an advisor for specific information.

EdD Degree

Offered In (Blacksburg)

TOEFL

Paper: (550.0)

Computer: (213.0)

iBT: (80.0)

The Ed.D. degree in Curriculum and Instruction with CTE concentration requires a minimum of 90 credits beyond the bachelor's degree. Please see the CTE program web site and consult an advisor for specific information.

PhD Degree

Offered In (Blacksburg)

TOEFL

Paper: (550.0)

Computer: (213.0)

iBT: (80.0)

GRE

General: Verbal, Quantitative, Analytical

The Ph.D. degree in Curriculum and Instruction with CTE concentration requires a minimum of 90 credits beyond the bachelor's degree. Please see the CTE program web site and consult an advisor for specific information.

GRADUATE COURSES (EDCT)

EDCT 5274:

Internship in Business

While employed in a business occupation, the student completes an In-depth study of the firms policies, practices, and procedures. Under the supervision of the employer and a Career and Technical Education professor, focuses on various aspects of the business. Pre-requisite:

Graduate Standing

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

EDCT 5604:**Foundations of Career and Technical Education**

Focus on the history and development of career and technical education with emphasis on the philosophical bases of the field. The conduct and purposes of career and technical education under different philosophical orientations are compared. An overview of the organization and administration, the relationship of career and technical education to agencies both in and outside of education, and how economic conditions have impacted career and technical education are explored. Definition and development of a personal philosophy is required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

EDCT 5614:**Curriculum Development in CTE**

Provides prospective career and technical education teachers with research bases, resources, and available curricula for teaching content in their respective fields. Develops the ability to plan, manage, develop, and evaluate curricula. Pre-requisite: Graduate standing in the CTE degree program.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

EDCT 5624:**Managing CTE Program**

Responsibilities of the career and technical education teacher regarding work-based program standards, student guidance, school and community relations, on-the-job training, youth organization sponsorship, work-based program coordination, and program management.

Prerequisite: Graduate Standing Required

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

EDCT 5634:**Curriculum and Instructional Processes in Career & Technical****Education**

Planning CTE courses and units of instruction to include industry competencies and academic standards of learning, performance objectives, and performance assessment. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

EDCT 5654:**Strategies for Teaching Career and Technical Education**

Focus on identifying the major instructional methods that are appropriate in career and technical education and identifying and resolving problems that emerge from these methods that can have a negative impact on the overall effectiveness of the teacher. Various methods to evaluate the teachers instructional effectiveness are addressed. Graduate standing or two years of teaching experience required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

EDCT 5684:**Advanced Curriculum Development & Program Mgmt in Career & Technical Educ**

Integrative learning development in Career and Technical Education (CTE) through incorporation of classroom and extracurricular experiences. Strategies and best practice to ensure interdisciplinary CTE cultural relevance. Methods of facilitating teacher professional development. Student safety.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): (EDCT 5614 OR EDCT 5634), EDCT 5624

Corequisite(s):

EDCT 5714:**Education and Work in a Changing Society**

This course explores the major social, economic, and political issues and trends expected to have continuing impacts on career and technical education and the workforce. The current status and philosophies of career and technical education are evaluated relative to these changes.

Alternative directions for the future are identified and analyzed, with emphasis on proactive rather than reactive strategies for educators.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): EDCT 5604 (UG) OR EDCT 5604

Corequisite(s):

EDCT 5754:

Internship in Education

Student participation in a planned clinical experience under supervision of a university staff member in an appropriate work center. (Max 12C).

Consent required.

Credit Hour(s): 1 TO 12

Lecture Hour(s): 1 TO 12

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

EDCT 5784:

Graduate Seminar in Education

Selected topics in career and technical education related to curriculum development, special education, administration, research, and evaluation. (Max 6C per course)

Credit Hour(s): 1 TO 6

Lecture Hour(s): 1 TO 6

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

EDCT 5894:

Final Examination

NONE

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

EDCT 5904:

Project and Report

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research, Online Research

Instruction Type(s): Research, Online Research

Prerequisite(s):

Corequisite(s):

EDCT 5954:

Study Abroad

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

EDCT 5964:

Field Study

NONE

Credit Hour(s): 1 TO 12

Lecture Hour(s): 1 TO 12

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

EDCT 5974:

Independent Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Independent Study

Instruction Type(s): Independent Study

Prerequisite(s):

Corequisite(s):

EDCT 5984:

Special Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

EDCT 5994:**Research and Thesis**

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research

Instruction Type(s): Research

Prerequisite(s):

Corequisite(s):

EDCT 6604:**Administrative Leadership for Career and Technical Education**

Administrative structure of career and technical education at the local, state, and national levels, and in business and industry; leadership for administrative planning, facilities and support services management, personnel management, supervision of instruction, professional development, and assessment in career and technical education.

Alternate years.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

EDCT 6614:**Evaluation in Career and Technical Education**

Study of the theory and application of evaluation to career and technical education. Major emphasis on the unique requirements of program, personnel and student evaluation as specified in Federal and State legislation and regulations. National and state evaluations of career and technical education are assessed.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

EDCT 6664:**Policy Analysis for Education and the Workforce**

In depth treatment of the nature of policy and the policy-making process as they pertain to the workforce and to education, especially to career and technical education. Included are significant aspects of policy development at local, state, and federal levels; examination of the basic questions that are answered by policy decisions; appropriate organizations for formulation of policy; an examination of current policy

pertaining to career and technical education at state and federal levels; and procedures for establishing policy.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): EDCT 5604 (UG) OR EDCT 5604

Corequisite(s):

EDCT 6944:**Professional Seminar**

Critical review, presentation, and discussion of current literature, research, and national reports in designated areas of education. (6C max. credit allowed toward program of study) Consent required.

Credit Hour(s): 1 TO 6

Lecture Hour(s): 1 TO 6

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

EDCT 6984:**Special Study**

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

EDCT 7754:**Internship in Education**

NONE

Credit Hour(s): 1 TO 12

Lecture Hour(s): 1 TO 12

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

EDCT 7964:**Field Studies in Education**

NONE

Credit Hour(s): 1 TO 12

Lecture Hour(s): 1 TO 12

179 Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

EDCT 7994:

Research and Dissertation

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research

Instruction Type(s): Research

Prerequisite(s):

Corequisite(s):

EDUCATION, COUNSELOR EDUCATION

Gerard Lawson, Program Director

Professors: Gerard Lawson;

Associate Professors: Nancy Bodenhorn; Laura Welfare;

Assistant Professors: Breanna Ellington; Matthew Fullen; Tameka Grimes;

Graduate Contact: glawson@vt.edu

Graduate Site: <http://www.soe.vt.edu/counselored/>

The Virginia Tech Counselor Education program offers a master's program (M.A.E.D) at the Virginia Tech Roanoke Center and a doctoral program (Ph.D.) at the main campus in Blacksburg. The Virginia Tech Counselor Education Master's program is a 60 credit hour program, which generally takes a full-time student two years to complete. The first summer and fall semesters of the program consists of classroom study, and beginning in the spring semester students are engaged in clinical study throughout the remainder of their program. Students who graduate with a master's degree in the school counseling track are qualified and endorsed by the faculty for licensure/certification as school counselors by the Virginia Department of Education. Those who graduate with a master's degree in the clinical mental health counseling track have completed all the courses required for LPC licensure in Virginia, and are prepared to enter the licensure residency period. Graduates need to complete additional hours of supervised practice to be eligible for licensure in Virginia, and can include their internship hours toward this state requirement. The Virginia Tech Counselor Education doctoral program prepares students to serve as counselor educators, clinical supervisors, or advanced clinicians, through coursework and practical training. Strong preference in admission is given to applicants with at least two years of post-masters clinical experience. Doctoral students complete advanced practica or internships in Teaching, Clinical Supervision, Clinical Practice, Research, and/or Professional Service and Outreach. Doctoral students in the Virginia Tech program have access to the latest instructional technologies, work closely with the faculty, and often collaborate on research, publications, and conference presentations. Students who complete the doctoral program typically seek employment as faculty members in counseling programs colleges

and universities, and in mental health settings in the community, hospitals, higher education, and K-12 schools. If students have not completed their LPC requirements prior to admission, courses and clinical doctoral internships can support that process.

SPECIAL FACILITIES

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DEGREES OFFERED

MA Degree

Offered In (Roanoke)

TOEFL

iBT: (90.0)

The masters program requires a minimum of 60 credit hours and a comprehensive exam, and the doctoral degree requires a minimum of 100 hours (post-baccalaureate) and a dissertation. Degree programs are accredited by the Council for Accreditation of Counseling and Related Educational Programs (CACREP) and by the National Commission of Accreditation and Teacher Education (NCATE). They are also approved by the Virginia Department of Education for the preparation of school counselors.

PhD Degree

Offered In (Blacksburg)

TOEFL

iBT: (90.0)

The masters programs require a minimum of 60 credit hours and a comprehensive exam, and the doctoral degree requires a minimum of 100 hours (post-baccalaureate) and a dissertation. Degree programs are accredited by the Council for Accreditation of Counseling and Related Educational Programs (CACREP) and by the National Commission of Accreditation and Teacher Education (NCATE). They are also approved by the Virginia Department of Education for the preparation of school counselors.

GRADUATE COURSES (EDCO)

EDCO 5204:

Orientation to Professional Counseling

Survey of the philosophy, scope, purposes, and methods employed in a variety of counseling settings including agencies, private practice, higher education, and elementary/middle/secondary schools with emphasis on services offered and professional identity and ethical issues.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

EDCO 5214:

Theories of Counseling & Consultation

Major theories used to understand and change behavior in a counseling setting. Emphasis is placed on the application of theoretical orientations to understanding and changing behavior of clients. Systematic integration of themes used in the counseling process, including consulting and coordination roles in school and community settings.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): EDCO 5204 (UG) OR EDCO 5204

Corequisite(s):

EDCO 5224:

Counseling Techniques

Systematic integration of techniques used in the counseling process. Course provides extensive practice, learning, integrating, and practicing skills characteristic of effective helping relationships. Extensive use is made of audio and video feedback in critiquing counseling interviews and techniques.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): EDCO 5214 (UG) OR EDCO 5214

Corequisite(s):

EDCO 5234:

Group Counseling

Introduction to group counseling theory and practice. Emphasis on application of group counseling principles to practical settings. In a laboratory setting, students receive feedback about their personal behavior in a group and supervised practice in the design, implementation, and evaluation of a short term group counseling project.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): (EDCO 5214 (UG), EDCO 5224 (UG)) OR (EDCO 5214, EDCO 5224)

Corequisite(s):

EDCO 5244:

Counseling Diverse Populations

Examination and application of counseling strategies for special client populations including the exceptional; economically disadvantaged; culturally, racially and ethnically different; those with different life styles. Emphasis on the range of human characteristics.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): EDCO 5204

Corequisite(s):

EDCO 5254:

Career Development and Information Services

Evolution of how the relationships of work and leisure have evolved into the concept of Career Development. Brief review of the major theories of Career Development and their application to the collection, evaluation, and use of career information in a variety of counseling/student development settings.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): EDCO 5204 (UG) OR EDCO 5204

Corequisite(s):

EDCO 5264:

Appraisal In Counseling

Various individual and group tests and informal approaches to better understanding of the individual in counseling. Case study methods examined in detail. Interpretation of test data and role of counselor in testing emphasized. Designed for masters level counselor preparation. 12 additional hours of suitable courses in education, psychology, or statistics required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): EDCO 5204 (UG), (EDRE 5404 (UG) OR EDCI 4604 (UG)) OR EDCO 5204, (EDRE 5404 OR EDCI 4604)

Corequisite(s):

EDCO 5284:

Practicum: Counselor Education

Supervised experience in the practice of counseling. Didactic instruction in advanced counseling techniques and methods coupled with practice with clients in a supervised setting. Extensive feedback on counseling practice in individual sessions and group seminar. Must have liability

previous course work in the field required. insurance.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): (EDCO 5204 (UG), EDCO 5214 (UG), EDCO 5224 (UG)) OR (EDCO 5204, EDCO 5214, EDCO 5224)

Corequisite(s):

EDCO 5344:

Systems Counseling

Use of systems theory in practice of counseling. Influence of systemic factors on human development, theories of family development, and counselors role to remedy institutional and social barriers. Emphasis on counseling skills including systemic case conceptualization and clinical intervention used with individuals, couples or families, and other systems.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): EDCO 5204

Corequisite(s):

EDCO 5354:

Addictions Counseling

Provides an overview of the strategies, goals, methodologies, programs and types of knowledge and skills necessary for effective identification and treatment of addictions Examines the classifications of drugs and other process addictions; impact of addictions on clients and their family members; components of addiction and recovery; prevention, treatment and relapse prevention resources; and salient legal and ethical guidelines. Graduate Standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

EDCO 5364:

School Counseling

Theory and practice of school counseling at the elementary, middle, and high school level, and introductory skills for those settings. Provides understanding of basic services performed by the school counselor; developmental characteristics of the age groups served; ethical, legal and societal issues that affect school counselors; special education

terminology; techniques useful in school counseling; and sources of materials available for educational and career counseling at various school levels.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): (EDCO 5204 (UG), EDCO 5214 (UG)) OR (EDCO 5204, EDCO 5214)

Corequisite(s):

EDCO 5374:

Clinical Mental Health Counseling

Counselor preparation for clinical mental health setting. Wellness, management of services and programs, counselor role and legal issues for a multi-cultural society in clinical mental health. Current controversies and professional issues.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): EDCO 5204, EDCO 5214

Corequisite(s):

EDCO 5424 (HD 5424):

Life Span Development

Stages of individual development as they occur in the context of the family life course. Overview of current developmental theories. Impact of race, gender, and class on cultural views of developmental norms.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

EDCO 5554:

Crisis Prevention, Preparedness, and Response

Assessment of school and community climate and principles of personal and community crisis prevention for counselors, teachers, and school administrators. Preparedness strategies appropriate for typical reactions to crises and relevant to special populations. Preparation and evaluation of crisis response plans that promote mental health and optimize potential for resilience and self-care. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

EDCO 5564:

Expressive and Experiential Techniques in Counseling

Basic principles and practices of intermodal expressive arts therapy.

Integration of expressive theories and techniques in individual and group counseling. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

EDCO 5604:

Graduate Seminar in Education

Selected topics in administration, counseling, adult and continuing education, research and evaluation, and community college and other domains of higher education. Emphasis is on interactive discourses on topics not typically included in regularly scheduled courses. (Maximum 3C per course).

Credit Hour(s): 1 TO 3

Lecture Hour(s): 1 TO 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

EDCO 5614:

Internship

Clinical experience (minimum 600 hours) under the supervision of a university staff member and a site supervisor in an appropriate field site: school (at least 300 hrs K-6 & at least 300 hrs 7-12), community agency, university counseling center, or other setting. Extensive feedback in individual sessions and group seminar. (12 hours minimum for program). Must have liability insurance.

Must have liability insurance.

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): EDCO 5284 (UG) OR EDCO 5284

Corequisite(s):

EDCO 5974:

Independent Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Independent Study

Instruction Type(s): Independent Study

Prerequisite(s):

Corequisite(s):

EDCO 5984:

Special Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

EDCO 5994:

Research and Thesis

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research

Instruction Type(s): Research

Prerequisite(s):

Corequisite(s):

EDCO 6304:

Clinical Supervision

A didactic and clinical study of supervision. Training in the differential conceptual approaches and the different methodologies of supervision, as well as the application of the theory and skills to actual supervisory processes with supervisees. Trainees will supervise masters students and document their supervision skills for clinical review. Students will supervise a counselor or intern as a part of the course and document with videotape. Must have liability insurance.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

EDCO 6324:

Professional Counselor Education and Supervision

and diversity issues. Council for Accreditation of Counseling and Related Educational Programs (CACREP) accreditation standards and process. Pedagogy, curriculum design and evaluation for adult learners relevant to counselor education and supervision. Program evaluation. Pre: Graduate Standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

EDCO 6404:

Advanced Counseling Theories and Multicultural Implications

Theories of counseling are examined in the context of contemporary research and practice, with particular attention to diverse populations and cultural influences. Effectiveness of selected past and contemporary counseling theories and practice with different populations is evaluated.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): (EDCO 5214 (UG), EDCO 5224 (UG)) OR (EDCO 5214, EDCO 5224)

Corequisite(s):

EDCO 6454:

Advanced Study in Career Development and Counseling Appraisal

Models and methods of assessment, use of data, approaches to program evaluation, effectiveness of models and treatment strategies, and theories pertaining to the principles and practice of career development and counseling.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): EDCO 5254, EDCO 5264

Corequisite(s):

EDCO 6474:

Advanced Practicum

Provides advanced graduate students in counseling/student development with in-depth supervision and student personnel experiences in various field settings. Experiences accompanied by intense faculty supervision and evaluation. (Maximum 12C). 30 hours previous coursework in the field required.

Credit Hour(s): 1 TO 12

Lecture Hour(s): 1 TO 12

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

EDCO 6484:

Leadership and Advocacy Issues in Counselor Education

Leadership and advocacy theories, skills, and strategies in professional counseling and counselor education as applied to school, clinical mental health counseling, and/or higher education settings. Ethical and cultural strategies and social justice implications of leadership and advocacy. Social and political issues impacting the counseling profession and the individual, systemic, and policy-level skills of advocacy. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

EDCO 6524:

Doctoral Internship

Provides advanced graduate students in Counselor Education with in-depth supervision and experiences in various field settings for a minimum of 600 clock hours. May include supervised experiences in a clinical setting, clinical supervision, and teaching. Includes most activities of a regularly employed professional in the setting. Experiences accompanied by intense faculty and on-site supervision and evaluation. (12 hours minimum required in program). Must have liability insurance and instructor consent.

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

EDCO 6534:

DSM Application in Counseling

Advanced study of the criteria of mental disorders and standard diagnostic and assessment procedures. Provides students with the extensive knowledge and skills necessary to differentiate abnormal from normal behavior in children and adults, with special emphasis upon the identification and assessment of the mental disorders included in the

will be on the application of the DSM in counseling situations.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

EDCO 6924:

Professional Seminar

Critical review, presentation, and discussion of current data-based and issues-related literature, either published or presented at recent national meetings. Provides students an opportunity to amalgamate their prior course experiences to produce a draft dissertation prospectus.

(Maximum 6C credit allowed toward program of study).

Credit Hour(s): 1 TO 6

Lecture Hour(s): 1 TO 6

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

EDCO 6984:

Special Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

EDCO 7704:

Field Studies in Education

Advanced applied research and/or evaluation study in one or more educational institutions or agencies. The student is graded on the basis of the design of the study and ability to conduct the study and report the results. (Maximum 12C).

Credit Hour(s): 1 TO 12

Lecture Hour(s): 1 TO 12

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

EDCO 7714:

Internship in Education

Planned program of advanced clinical practice in education through assignment under direct supervision of outstanding practitioner for periods of up to two semesters. (Maximum 24C).

Credit Hour(s): 1 TO 24

Lecture Hour(s): 1 TO 24

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

EDCO 7994:

Research and Dissertation

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research

Instruction Type(s): Research

Prerequisite(s):

Corequisite(s):

EDUCATION, CURRICULUM AND INSTRUCTION

Emeriti Faculty: Susan Asselin; John Burton; Daisy Cartwright; Patricia Kelly;

Susan Magliaro; David Moore; Mark Sanders; Thomas Sherman; Richard Stratton;

Josiah Tlou; Terry Wildman;

Professors: Bonnie Billingsley; Katherine Cennamo; Peter Doolittle; James

Garrison; Kristin Gehsmann; George Glasson; David Hicks; Glen Holmes; Brett

Jones; Bettibel Kreye; Barbara Lockee; Heidi Mesmer; H Sutphin; Marcus Weaver-

Hightower; John Wells; Jesse Wilkins;

Associate Professors: Amy Azano; Mary Barksdale; Brenda Brand; William Price;

Trevor Stewart; Gresilda Tilley-Lubbs; Catherine Ulrich; Thomas Williams;

Assistant Professors: Bradley Bowen; Joseph Mukuni; Kenneth Potter; Takumi

Sato;

Visiting Faculty: Alicia Johnson;

Affiliated Faculty: Liesl Baum Walker; Thomas Broyles; Charles Burnsed; Edward

Ewing; John Moore; Rickie Rudd; James Washenberger;

Instructor(s): Kenneth Potter;

Assistant Professor of Practice: Nancy Bradley; Donna Fogelson; Catheryn

Foster;

General Contact: nanboden@vt.edu

School of Education: <http://www.soe.vt.edu/index.php>

The Curriculum and Instruction graduate degrees are offered by 13 programs in the School of Education. Listed below is contact information

for all of the programs, followed by degree information for the programs that use the Curriculum and Instruction degrees. The Career and Technical Education (CTE) program has its own Master's Degree and is described in a different section. Career and Technical Education Program Leader: Joseph Mukuni (mjoseph7@vt.edu, 540-231-0919) Website: <https://liberalarts.vt.edu/departments-and-schools/school-of-education/academic-programs/career-and-technical-education.html> (See Career and Technical Education for Masters degree information.) Educational Psychology Program Leader: Brett Jones (jones1@vt.edu, 540-231-8328) Website: <https://liberalarts.vt.edu/departments-and-schools/school-of-education/academic-programs/educational-psychology.html> Elementary Education Program Leader: Donna Fogelsong (donnafogelsong@vt.edu, 540-232-8466) Website: www.soe.vt.edu/elementaryed/index.html English Education Program Leader: Trevor Stewart (ttstew@vt.edu), 540-231-8335) Website: <http://www.soe.vt.edu/englished/index.html> Foundations of Education Program Leader: Jim Garrison (wesley@vt.edu, 540-231-8331) Website: <https://liberalarts.vt.edu/departments-and-schools/school-of-education/academic-programs/foundations-of-education.html> History and Social Science Education Program Leader: David Hicks (hicks@vt.edu, 540-231-8332) Website: <https://liberalarts.vt.edu/departments-and-schools/school-of-education/academic-programs/history-and-social-science-education.html> Instructional Design and Technology Program Leader: Ken Potter (kpotter@vt.edu, 144 Smyth Hall, 540-231-7039) Website: www.soe.vt.edu/idt/index.html Integrative STEM Education Program Leader: John G. Wells, (jgwells@vt.edu, 540-231-8471) Website: <https://tinyurl.com/VT-I-STEM-ED> Mathematics Education Program Leader: Jay Wilkins (wilkins@vt.edu, 540-231-8326) Program Leader, Secondary Licensure in Mathematics: Betti Kreye (bkreye@vt.edu, 540-231-8348) Program Leader, K-8 Mathematics Specialist Program, Jay Wilkins (wilkins@vt.edu, 540-231-8326) Website: <http://www.mathed.soe.vt.edu/> Music Education Program Leader: Catheryn Foster (csfoster@vt.edu, 540-231-9423) Website: <https://liberalarts.vt.edu/departments-and-schools/school-of-education/academic-programs/music-education.html> Reading Specialist/Literacy Program Coordinator: Heidi Anne Mesmer (hamesmer@vt.edu, 540-231-8343) Website: <https://liberalarts.vt.edu/departments-and-schools/school-of-education/academic-programs/reading-specialist.html> Science Education Program Leader: George Glasson (glassong@vt.edu, 540-231-8346) Website: <https://liberalarts.vt.edu/departments-and-schools/school-of-education.html> Special Education Program Leader: Thomas Williams (thwilli1@vt.edu, 540-231-8337)

SPECIAL FACILITIES

DEGREES OFFERED

EdS Degree

Offered In (Blacksburg)

TOEFL

iBT: (90.0)

There are M.A., Ed.S., Ed.D. and Ph.D. degrees offered in Curriculum and Instruction. The specific requirements vary among the programs that award these degrees. Please see information on each program included in the Additional Information section and refer to program web sites for specific requirements.

EdD Degree

Offered In (Blacksburg)

TOEFL

iBT: (90.0)

There are M.A., Ed.S., Ed.D. and Ph.D. degrees offered in Curriculum and Instruction. The specific requirements vary among the programs that award these degrees. Please see information on each program included in the Additional Information section and refer to program web sites for specific requirements.

MAEd Degree

Offered In (Blacksburg, Virtual)

TOEFL

iBT: (90.0)

There are M.A., Ed.S., Ed.D. and Ph.D. degrees offered in Curriculum and Instruction. The specific requirements vary among the programs that award these degrees. Please see information on each program included in the Additional Information section and refer to program web sites for specific requirements.

PhD Degree

Offered In (Blacksburg)

TOEFL

iBT: (90.0)

GRE

General: Verbal, Quantitative, Analytical

There are M.A., Ed.S., Ed.D. and Ph.D. degrees offered in Curriculum and Instruction. The specific requirements vary among the programs that award these degrees. Please see information on each program included in the Additional Information section and refer to program web sites for specific requirements.

GRADUATE COURSES (EDCI)

EDCI 5104:

Schooling in American Society

A study of the people and forces that impact on American education, analyzing the social setting of schooling and the relationships among school, curriculum, clients, personnel, and culture.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

EDCI 5124:**Behavioral Aspects of Music**

Behavioral foundations of music research examining the influence of music on the performer and the listener. Perception, reaction, moods, powers of discrimination, and musical acoustics.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

EDCI 5134:**Gender and Education**

Introduction to gender in the context of education. This course is intended to raise awareness of how gender is implicated in teaching and learning in K-12 schooling and higher education. School policy as it relates to gender equality and sex education. Theoretical frameworks for gender analysis in education. Pre-requisite: Graduate standing required

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

EDCI 5204:**Elem Sch Curriculum**

This course is concerned with the development of the elementary school curriculum. It deals with the structure, characteristics, problems and practices of the elementary school curriculum, the children, the environment and the school setting. The course is also concerned with the process of curriculum improvement and its implementation in contemporary elementary schools.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

EDCI 5214:**Linguistic Theory and Instruction in Reading and Written Expression**

Studies the syntactic structure of questions and their function and application to selected questioning strategies in reading and writing;

explores ideas for the development of a systematic approach to teaching writing in conjunction with reading; discusses the use of stylistic devices and grammars in a reading and writing program using basal readers and childrens literature.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): EDCI 5004 (UG) OR EDCI 5004

Corequisite(s):

EDCI 5224:**Advanced Curriculum & Instruction in Elementary & Middle Sch Social Studies**

Emphasizes curriculum research and recent developments in trends and materials in elementary and middle school social studies instruction.

Exploration of alternative approaches in instructional strategies. (1-3H, 1-3C).

Credit Hour(s): 1 TO 3

Lecture Hour(s): 1 TO 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

EDCI 5234:**Advanced Curriculum and Instruction in Elem & Middle School Mathematics**

Research and recent developments in elementary and middle school math curricula; study and analysis of recent trends and materials; and examination of alternative approaches in methodology. (1-3H, 1-3C).

Credit Hour(s): 1 TO 3

Lecture Hour(s): 1 TO 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

EDCI 5244:**Advanced Curriculum and Instruction in Elementary and Middle School Science**

Selected study and analysis of curriculum trends, methods and materials. Emphasis on recent developments and the practical implications of research in science education. (1-3H, 1-3C).

Credit Hour(s): 1 TO 3

Lecture Hour(s): 1 TO 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

EDCI 5264:

Comprehending Processes and Reading in the Content Areas

Explores basic processes involved in comprehension: the role of concepts about text structure, task demands, and the role of the reader; includes teaching strategies for comprehending and using information in content area texts and in job related materials.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

EDCI 5274:

Curriculum and Instruction in Elementary School Mathematics (Pre-K-3)

Key concepts in curriculum and instruction: mathematical thinking, number and number sense, geometry and measurement, computation and estimation, and teaching methods in grades Pre K-3 mathematics.

Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

EDCI 5284:

Curriculum and Instruction in Middle School Mathematics (4-8)

Key concepts in curriculum and instruction in grades 4-8 mathematics: mathematical thinking, algebraic reasoning, fractions, decimals, percents, and probability and statistics. Teaching mathematics through problem solving, reasoning, and communication. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

EDCI 5304:

Assessment for K-12 Literacy Instruction

Examines theory and practice of assessment in literacy education.

Explores the range of current paradigms, including those associated with assessment as measurement, as procedure, and as inquiry. Focuses on the reciprocal relationship between assessment and instruction in literacy practices. Explores a variety of assessment practices and their appropriateness for use with a diverse student population.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): EDCI 5004 (UG) OR EDCI 5004

Corequisite(s):

EDCI 5324:

Language, Literacy, and Culture (K-12)

The course assists educators in furthering their understanding of the connection between language, and the role culture plays within literacy development. Emphasizes how educators within the school context (K-12) need to be aware of, and utilize, the cultural background knowledge and linguistic resources, community needs of diverse students, and the community groups in which they belong. Major emphasis is on issues of literacy development in regard to oral, written, and multi-mediated texts. Graduate standing is required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

EDCI 5334:

Conducting Literacy Inquiry

Course content develops student skills in analysis of classroom research studies and development of a mind set for becoming a teacher researcher. Familiarizes students with classroom research methodologies that provide the practitioner with skills for conducting a teacher research project within school contexts. Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

EDCI 5344:

Review of Literary Research

Examines the methods and knowledge developed through the major traditions in literacy research and the social and political forces through which these traditions have been shaped. Graduate standing is required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

EDCI 5364:

Technology in the Science Classroom

Strategies for effective implementation of technology in science classrooms (K-12) to support student learning. Technology examples include digital resources, software and applications, and internet tools specific to science education. Planning and analyzing the use of technology to support science practices, technology skill development, student assessment, and improving teacher practices. Principles of effective on-line portfolio development. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

EDCI 5374:

Assessment in K-12 Science Education

Roles, types, research, and development of assessments as practiced in inquiry-based science education. Impact of high stakes testing.

Principles of aligning assessment with standards of learning and lesson objectives with goal of assessment as a tool for learning. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

EDCI 5404:

Practicum in Clinical Reading

Diagnosis and remediation of reading problems. Each student works with children (K-12) in a clinical setting. The student is responsible for collecting relevant data, designing an appropriate program, carefully monitoring, and communicating progress in formal and informal reporting.

Credit Hour(s): 0 OR 3

Lecture Hour(s): 0 OR 2

Instruction Type(s): Lab, Lecture, Online Lecture

Instruction Type(s): Lab, Lecture, Online Lecture

Prerequisite(s): (EDCI 5004 (UG), EDCI 5304) OR (EDCI 5004, EDCI 5304)

Corequisite(s):

EDCI 5414:

Theory and Practice for Early Literacy Instruction (PK-3)

Examines language development and early literacy teaching and learning. Explores a wide range of current theories and practices including phonics based and meaning based approaches to teaching. Attends to how curriculum, instruction, and assessment reflect differing agendas for literacy and schooling and different definitions of literacy. I.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

EDCI 5424:

Theory and Practice in Content Literacy Instruction (3-6)

Focuses on comprehension and literacy development in middle grades. It explores a wide range of paradigms of comprehension and attends to how curriculum, instruction, and assessment are conducted within each paradigm. Special attention is given to socio-cultural and critical perspectives within literacy pedagogy.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): EDCI 5414 (UG)

Corequisite(s):

EDCI 5444:

Teaching Adolescent Readers

Examination of active reading processes, instructional strategies, and appropriate adolescent literature for teaching both the developmental and the remedial reader in secondary language arts. Admission in a graduate teacher education program or instructor permission required. Prerequisite: Graduate standing admission into a teacher education program or instructor permission.

Credit Hour(s): 3

Lecture Hour(s): 3

189 Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

EDCI 5454:

Teaching Composition

Investigation of theory and research into pedagogy in teaching composition in K-12 settings. Consideration of the reasons K-12 students write, the ways they learn to write, and the genres and forms they utilize. Prerequisite: Graduate standing, admission into a graduate teacher education program or instructor permission.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

EDCI 5524:

Behavior Management in K-12 Classrooms

Analysis and application of research-based instructional and behavioral techniques for supporting individuals in the K-12 classroom. Trends, assessment, ethics, and collaborative involvement in behavior management. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s):

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

EDCI 5554:

Educating Exceptional Learners Across the Lifespan

Analysis of purpose, rationale, and foci of educational programs, and related services for individuals with special needs. Identification of characteristics associated with each exceptionality. Review of procedures for assessment, eligibility decisions, and the development of individualized educational programs. Overview of selected instructional strategies, environmental adaptations, and special materials. Examination of findings concerning program efficacy.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

EDCI 5555:

Reading Specialist Practicum

The practicum develops the skills necessary to enhance school-based learning communities focused on literacy development (K-12) by providing professional development opportunities for teachers and paraprofessionals. The first of the sequence of two courses details the planning process of designing a literacy program within a school context that will identify and provide resources for teachers, administrators, and parents. The second course in the sequence provides the opportunity to implement and assess the literacy plan and to communicate the purposes of the literacy plan to policy makers and the community. Graduate standing is required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

EDCI 5556:

Reading Specialist Practicum

The practicum develops the skills necessary to enhance school-based learning communities focused on literacy development (K-12) by providing professional development opportunities for teachers and paraprofessionals. The first of the sequence of two courses details the planning process of designing a literacy program within a school context that will identify and provide resources for teachers, administrators, and parents. The second course in the sequence provides the opportunity to implement and assess the literacy plan and to communicate the purposes of the literacy plan to policy makers and the community. Graduate standing is required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

EDCI 5604:

Assessment and Diagnosis for the Mathematics Classroom

Research in assessment and diagnosis in K-8 mathematics. Ethical uses of assessment tools, questions, early mathematical ability, compare evaluation and assessment, develop model assessment. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

EDCI 5605:

Leadership in Mathematics Education

This course sequence focuses on the leadership roles of school-based mathematics education teacher leaders. 5605: Teacher coaching strategies, co-planning, co-teaching, and professional development approaches for K-8 mathematics education leaders. 5606: Leadership roles and responsibilities for K-8 mathematics education leaders working with adults. Strategies and rationale for mathematics instruction for diverse learners. Pre: Graduate standing for 5605.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

EDCI 5606:

Leadership in Mathematics Education

This course sequence focuses on the leadership roles of school-based mathematics education teacher leaders. 5605: Teacher coaching strategies, co-planning, co-teaching, and professional development approaches for K-8 mathematics education leaders. 5606: Leadership roles and responsibilities for K-8 mathematics education leaders working with adults. Strategies and rationale for mathematics instruction for diverse learners. Pre: Graduate standing for 5605.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): EDCI 5605

Corequisite(s):

EDCI 5614 (MATH 5614):

Topics for In-Service Teachers

Various topics in mathematics and its applications to real-life problems, presented in light of contemporary instructional technologies and standards of learning. The course is designed for in-service mathematics teachers at the high and middle school levels and is suitable for recertification credit. The specific topics covered will be tailored to the location and delivery mode of the course, as well as evolving standards and methodology. May be applied toward graduate degrees in mathematics. In-service status required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

EDCI 5704:

Contemporary Issues in Music Education

Selective study and analysis of historical and recent curriculum trends and materials; discussion and evaluation of research. Focus on socio-cultural, equity, philosophical, learner-centered, curriculum, assessment, technology, and critical pedagogical perspectives within K-12 music education. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

EDCI 5714:

Topics in Mathematics Education

Close examination of a discipline, topic, or group of questions in mathematics education. Examples include construction of number, teaching and learning of probability and statistics, understanding quantitative literacy. Explore current research, different conceptions and construction of knowledge on topic. Data collection and analysis on topic. May be repeated three times with different content for a maximum of twelve credits. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

EDCI 5724:

Teaching in Middle and Secondary Schools I

Introduces concepts and methods that enhance the teaching of specific academic disciplines (English, history and social sciences, science, mathematics, foreign languages, and music) in combination with a field studies course.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

EDCI 5734:

Critical Analysis of Mathematics Education Research

Classical, seminal, and current works in the field of mathematics education. Mathematics education research. Theoretical frameworks, methodologies, claims and implications. Pre: Graduate Standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

EDCI 5744:

Teaching in Middle and Secondary Schools II

Intensive instruction in methods of teaching an academic discipline (English, history and social science, science, mathematics, foreign languages, and music). Emphasis on classroom management, use of instructional technology, planning and delivery.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

EDCI 5754:

Internship in Education

Student participation in a planned clinical experience under supervision of a university staff member in an appropriate work center.

Credit Hour(s): 1 TO 12

Lecture Hour(s): 1 TO 12

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

EDCI 5764:

Externship in Education

Special interdisciplinary problem-solving clinics for experienced educational practitioners who are engaged part-time in graduate study while continuing in positions of leadership in education. Interdisciplinary teams of faculty work with small groups of experienced supervisors or instructors in systematic analysis of current educational problems and evaluation of educational practice. Students judged on quality of their investigations, individual reports, and discussion. (Maximum 12C).

Consent required.

Credit Hour(s): 1 TO 12

Lecture Hour(s): 1 TO 12

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

EDCI 5774:

Problems in Education

Study of problems of professional educators in such areas as supervision, instruction, and curriculum development.

Credit Hour(s): 1 TO 6

Lecture Hour(s): 1 TO 6

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

EDCI 5784:

Graduate Seminar in Education

Selected topics in curriculum and instruction, supervision, educational foundations, special education, research, and evaluation.

Credit Hour(s): 1 TO 6

Lecture Hour(s): 1 TO 6

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

EDCI 5804:

STEM Education Foundations

Provides an introduction to the nature of the science, technology, engineering, and mathematics (STEM) disciplines, and their corresponding STEM education disciplines; the inherent connections, confluences, and differences among the STEM and STEM education disciplines; the frameworks, standards, and infrastructures that govern the teaching of these subjects in K-16 STEM education; and other social, political, theoretical, and philosophical ideas and influences that underlie K-16 STEM education. Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

EDCI 5814:**STEM Education Pedagogy**

Provides an ordered investigation into the instructional practices and signature pedagogies of science, technology, engineering, and mathematics (STEM) disciplines as a means for developing purposefully integrative approaches for teaching/learning the content of these disciplines. Through study of the epistemologies, philosophies, strengths, and limitations associated with STEM signature pedagogies, students come to know a set of blended pedagogical practices that serve to enhance individual practices within their chosen fields. Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

EDCI 5824:**STEM Education Trends & Issues**

An exploration of contemporary K-16 Science, Technology, Engineering, and Mathematics (STEM) education trends and issues, including both integrative and within-discipline STEM education trends/issues. Topics addressed include STEM literacy, integrative approaches to STEM education, the changing role of design and inquiry in STEM education, STEM education-related legislation, change theory, state and federal funding, and extracurricular STEM education initiatives. Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

EDCI 5834:**STEM Education Research**

Designed as a structured investigation into the educational research methods and priorities among the science, technology, engineering, and mathematics (STEM) education disciplines. This course examines the various research methodologies used in studying teaching/learning issues within the context of STEM education disciplines. Students examine the similarities, distinctions, and overlaps among questions posed, research designs, and methods of studying best practices in order to better understand the teaching and learning processes among STEM education disciplines. Student gains in their understanding of these processes serve as the framework for preparing individual STEM-

related action research proposals. Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

EDCI 5844:**STEM Education Seminar**

An open forum for the exploration of topics and issues reflective of the national educational reform efforts impacting the science, technology, engineering, and mathematics (STEM) disciplines, with particular attention to the broader context of concerns for developing a technologically literate populace within our educational system. Through a blend of readings, presentations, discussions, expeditions, and reflections on personal experiences, students develop an appreciation for STEM discipline perspectives relative to the educational process. Graduate standing required.

Credit Hour(s): 1

Lecture Hour(s): 1

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

EDCI 5854:**Biotechnology Literacy By Design**

Addresses the field of biotechnology through technological design as a core curricular requirement reflective of the national Standards for Technological Literacy (STL) (ITEA, 2000). Using problem/project-based instruction, students develop a level of general science, technology, engineering, and mathematics (STEM) education literacy necessary for K-12 STEM educators to teach about biotechnology from a technological/engineering design approach. Students examine the content areas of biotechnology and apply the technological design method as they explore a variety of purposefully designed integrative instructional strategies for teaching at the intersections of the STEM disciplines. This project-oriented course provides students with the opportunity to apply instructional theories, principles, and practices in the design of authentic problem-based instructional units appropriate for inclusion into the K-12 STEM Education curriculum. Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

EDCI 5894:

Final Examination

NONE

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

EDCI 5904:

Project and Report

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research, Online Research

Instruction Type(s): Research, Online Research

Prerequisite(s):

Corequisite(s):

EDCI 5914:

Diversity & Multicultural Educ in the Teaching of Engl Language

Learners

Issues in diversity and multicultural education applied to teaching, PK-12 and adult English language learners. Reflections and articulation of personal cultural perspectives. Principles for developing classrooms that foster equity and access to academic success for all students.

Integration of interdisciplinary planning and teaching of core content lessons for English language learners. Graduate Standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

EDCI 5924:

Research in Educating English Language Learners

Principles of research in the education of English language learners in diverse and multicultural K-12 classrooms and community settings.

Analysis of published research and evaluation of discrepancies between practice and research in English language learner populations.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): EDCI 5914 OR EDCI 5914 (UG)

Corequisite(s):

EDCI 5964:

Field Studies in Education

Applied study in one or more educational institutions. Research, evaluation, curricular, and instructional projects are examples of appropriate projects of study. The student is graded on the basis of the design of the project and ability to carry it through and report the results.

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

EDCI 5974:

Independent Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Independent Study, VI

Instruction Type(s): Independent Study, VI

Prerequisite(s):

Corequisite(s):

EDCI 5984:

Special Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

EDCI 5994:

Research and Thesis

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research

Instruction Type(s): Research

Prerequisite(s):

194 Corequisite(s):

EDCI 6014:**Advanced Topics in Teacher Education Curriculum**

Intensive study of research findings and methods in preservice teacher education. Focus on internal and external issues that affect the curriculum, guidelines, accreditation, governance, alternative models, and approaches, instructional strategies, and history of teacher education reform. May be repeated to a maximum of 6 semester hours.

Pre-requisite: Graduate Standing required.

Credit Hour(s): 1 TO 6

Lecture Hour(s): 1 TO 6

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): EDCI 5104

Corequisite(s):

EDCI 6024:**The Analysis of Educational Concepts**

Systematic introduction to the study of contemporary philosophy of education, indicating ways in which philosophy is used to analyze educational aims, content, methods, and values.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): EDCI 5104

Corequisite(s):

EDCI 6034:**Education and Anthropology**

Exploration of anthropological ideas and findings relevant to educational institutions and the teaching/learning process. Emphasis on how sociocultural patterns affect what is taught and learned.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): EDCI 5104

Corequisite(s):

EDCI 6054:**Acad Writing for Qual Ed Res**

Writing workshop in which students work toward a personal goals (manuscript, book review, conference proposal, or fellowship application). Emphasis on how writing operates in the production, circulation, and elevation of knowledge in high education. Writing for qualitative research in education is the focus of this course.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): EDRE 6504

Corequisite(s):

EDCI 6505:**Reading Research Seminar**

Issues related to conducting and reporting research on the reading process and reading pedagogy. Includes the critical review of classical and contemporary research and an initiation to the process of conducting reading research. Special attention is given to the analysis and classification of major research paradigms.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): (EDCI 5004 (UG), EDCI 5304 (UG)) OR (EDCI 5004, EDCI 5304)

Corequisite(s):

EDCI 6506:**Reading Research Seminar**

Issues related to conducting and reporting research on the reading process and reading pedagogy. Includes the critical review of classical and contemporary research and an initiation to the process of conducting reading research. Special attention is given to the analysis and classification of major research paradigms.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): EDCI 6505 (UG) OR EDCI 6505

Corequisite(s):

EDCI 6534 (EDRE 6534):**Ethnographic Methods in Educational Research**

Exploration of ethnographic methods for data collection and analysis: theoretical bases, procedures, issues, and applications of this approach in educational research.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): EDCI 6034

195 Corequisite(s):

EDCI 6944:**Professional Seminar**

Presentation and critical discussion of current literature and major topics in curriculum and instruction. Provides students an opportunity to synthesize prior course experiences and to prepare and present a draft dissertation prospectus.

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

EDCI 6984:**Special Study**

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

EDCI 7754:**Internship in Education**

Planned program of advanced clinical practice in education through assignment under direct supervision of an outstanding practitioner for periods of up to two semesters.

Credit Hour(s): 1 TO 24

Lecture Hour(s): 1 TO 24

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

EDCI 7964:**Field Studies in Education**

Advanced applied study in one or more educational institutions. Research, evaluation, curricular, and instructional projects are examples of appropriate projects of study. The student is graded on the basis of the design of the study, ability to conduct the study, and interpret and report the results.

Credit Hour(s): 1 TO 12

Lecture Hour(s): 1 TO 12

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

EDCI 7994:**Research and Dissertation**

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research, Online Research

Instruction Type(s): Research, Online Research

Prerequisite(s):

Corequisite(s):

EDUCATION, EDUCATIONAL LEADERSHIP AND POLICY STUDIES

Carol Cash, Program Director

Emeriti Faculty: Glen Earthman; David Parks; Richard Salmon; Travis Twiford; Wayne Wornor;

Professors: Michael Alexander; Carol Cash; Carol Mullen;

Associate Professors: William Glenn; John Gratto;

Visiting Faculty: Ted Price;

Assistant Professor of Practice: Jodie Brinkmann;

General Contact: nanboden@vt.edu

Educational Leadership: <http://www.soe.vt.edu/edad/>

Program Leader: Carol Cash, (ccash48@vt.edu, Virginia Tech Richmond Center, 2810 Parham Road, Suite 300, Richmond, VA 23294) Graduate Program Director: Nancy Bodenhorn, (nanboden@vt.edu, 540-231-8180) Web site: <http://www.soe.vt.edu/edad/> This is a graduate program developed by Virginia Tech to prepare educational administrators for leadership roles in school systems and related agencies. Admissions Process and Selection Criteria: Admission to graduate study in educational leadership requires acceptance by both the Educational Leadership and Policy Studies program and Virginia Tech's Graduate School. Admission criteria are: An appropriate degree; A grade point average (GPA) of at least 3.3 (on a 4.0 = A scale) on previous graduate work for admission to a doctoral degree program or 3.0 for admission to a master's degree or Ed.S. degree program; Administrative/leadership experience for the doctoral degree; Strong communication skills; At least 3 strongly supportive letters of recommendation, one from the applicant's superintendent is preferred and two from other professional associates; A successful interview with a faculty committee from Virginia Tech; Scores on the Graduate Record Examination are required for the Ph.D. option. Doctoral Program in Educational Leadership Degrees Offered: Successful completion of the program will result in award of the Ph.D. or Ed.D. in Educational Leadership and Policy Studies. Locations: Educational Leadership offers doctoral programs at the following locations: Blacksburg campus of Virginia Tech/Virginia Tech Center at

Higher Education Center in Roanoke Virginia Tech Northern Virginia Center in Falls Church Virginia Tech Hampton Roads Center in Virginia Beach Virginia Tech Richmond Center Virginia Tech Center at the Southwest Virginia Higher Education Center in Abingdon The EdD degree program is organized and delivered at each site in cohorts of approximately 15 students who are practicing professionals. The PhD option is available on the Blacksburg campus to students who wish to pursue university teaching or careers in policy related work. Only a few students are admitted into the Ph.D. option each year. The number of admissions is limited so that faculty may offer students the support and guidance they need. Curriculum: Successful candidates will complete a minimum of 63 postmaster's credits for the Ed.D. and 69 postmaster's credits for the Ph.D. The program extends over a 36-month period and covers coursework in foundations, applied studies, research, cognates, and the dissertation. Part-time students take at least two courses each semester, including each summer session over approximately a three-year period. Coursework includes, but is not limited to, governance and policy, quantitative and qualitative research methods, literature reviews, advanced school law, advanced school finance, legal aspects of special education, theories of educational administration, planning educational facilities, and administration of instructional programs. Special topics will cover school safety, testing and the Standards of Learning, school accreditation, diversity, ethics, and the politics of education. An individual program of studies is planned for each student and depends upon the student's previous academic record, background, and interests. Master's or Education Specialist Program in Educational Leadership The Program for the Preparation of School Principals and Supervisors began in the fall of 1989 following an eighteen-month study of school leadership by practicing administrators and supervisors, university faculty, and state department of education officials. The resulting cohort program is learning centered, field sensitive, team taught, technologically and resource rich, performance driven, and problem oriented. It is offered in Northern Virginia, Hampton Roads, Richmond, Roanoke, Abingdon, Blacksburg, and at other sites in Virginia. It is also offered Virtually, beginning in 2018. It is reviewed and revised annually to meet the changing needs of school leaders. Applicants who have previously earned a master's degree may complete an Education Specialist (Ed.S.) degree through this program. Sense of Purpose: Talented educators are prepared through this program for positions in school administration and supervision. Graduates are able to work collaboratively with teachers, students, parents, and community leaders in the development of school programs that encourage and promote the growth of all students. They possess the management skills needed to support a productive learning environment for students and teachers. They have the ability to work side-by-side with educators, parents, and community agencies in developing, implementing, and evaluating programs designed to prevent or to confront learning and behavioral difficulties. They are able to work with teachers, children, parents, and community members with diverse needs, views, and values. They have a professional code of ethics and are able to function effectively within local, state, and federal laws, rules, and regulations. Above all, they are caring and competent human beings. A Practical Knowledge Base: The program is based on the Professional Standards for Educational Leaders (PSEL), and is accredited by the Council for Accreditation of Educator Preparation (CAEP) and the Virginia Department of Education (VDOE). Further, the knowledge and skill objectives were identified, and are periodically reviewed, by practicing school administrators and supervisors. These standards and objectives are incorporated into the courses and internship experiences of the program. Heavy emphasis is placed on student learning, collaborative leadership, a productive culture, shared decision making, and planned change. Facilitative Instructional Practices: Courses are performance based and technologically rich. Students use case materials, simulations, and real-life problems to learn

various approaches to decision making and problem solving. Both faculty and students favor problem-based learning; it is now used in one form or another in all courses. Both video conferencing and computer-based learning management software are used to facilitate communication among individual students and faculty, among small groups, and between cohorts. An internship begins in the first semester and continues for the entire program. Interns select, with the approval of the campus supervisor, a mentor. A minimum of 350 clock hours with a minimum of 120 clock hours directly focused on improving student learning is required. The intern works a minimum of 120 clock hours at one school level; a minimum of 40 clock hours at the other school levels (elementary, middle, or high); a minimum of 40 clock hours at the central office; and a minimum of 30 clock hours in agencies that deal with children or families. All experiences are on site and are designed to meet the required objectives spelled out in the internship manual. The mentor or campus supervisor approves all experiences used for the completion of objectives. At least one reading is selected to facilitate the achievement of each objective in the internship. Reflections on the experiences, the readings, and the relationship between the two are recorded in a log, which is regularly reviewed by the on-site and campus supervisors. Selection Procedures: Students are carefully selected for the program. Applicants submit an application form with the usual demographic information; a letter of application describing previous leadership experiences, motives for becoming a school leader, and commitments to education and school administration or supervision; and letters of recommendation from three persons. An interview is conducted using a protocol to assess the applicant's academic potential, commitment to becoming a principal or supervisor, commitment to completing the program, communication skills, educational values, interpersonal skills, leadership potential, teaching experience and performance, and technological competence Two writing samples are required for admission. A sample of the student's best writing is submitted with the application package. Written responses within the supplemental portion of the application are also reviewed for substance and structure. Faculty members, community members, practicing school leaders, and sometimes teachers serve on the interview committee. After a review of materials and the interview, those students with the highest ratings are invited to join the program. Use of Technology: Faculty members integrate instructional technology in every course. The Canvas online course management system may be used to supplement on-site teaching. Video conferencing systems, like ZOOM, connect cohorts across sites. Graduates use distance learning equipment and software, courseware such as Canvas, spreadsheets, scheduling and record keeping software, and presentation software such as Corel's Presentations and Microsoft's PowerPoint throughout the program. They meet the state's technology standards for teachers and administrators, and they have the skills needed to evaluate instructional and managerial software. Please see the Educational Leadership web site for specific requirements for all degrees.

SPECIAL FACILITIES

DEGREES OFFERED

MA Degree

Offered In (Roanoke, Richmond, Virtual, Hampton Roads, Southwest Virginia, National Capital Region)

TOEFL

iBT: (90.0)

The Educational Leadership Program offers the M.A.Ed. degree in Hampton Roads, National Capital Region, Richmond, Roanoke, Southwest Virginia and Virtually. Please refer to the program website for specific requirements.

PhD Degree

Offered In (Blacksburg)

TOEFL

iBT: (90.0)

The Educational Leadership Program offers the Ph.D. degree only in Blacksburg. Please refer to the program website for specific requirements.

EdD Degree

Offered In (Roanoke, Richmond, Hampton Roads, Southwest Virginia, National Capital Region)

TOEFL

iBT: (90.0)

The Educational Leadership Program offers the Ed.D. degree in Hampton Roads, National Capital Region, Richmond, Roanoke, and Southwest Virginia. A virtual option will be available in Fall 2020. Please refer to the program website for specific requirements.

EdS Degree

Offered In (Roanoke, Richmond, Hampton Roads, Southwest Virginia, National Capital Region)

TOEFL

iBT: (90.0)

The Educational Leadership Program offers the Ed.S. degree in Hampton Roads, National Capital Region, Richmond, Roanoke, and Southwest Virginia. Please refer to the program website for specific requirements.

GRADUATE COURSES (EDEL)

EDEL 5004:

School Personnel Administration and Instructional Supervision

Administration and supervision of human resources and instructional programs in schools. Content encompasses human resources planning, recruitment, selection, assignment, induction, supervision and appraisal, development, compensation and benefits, employee relations, and other topics of current interest.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

EDEL 5024:

School Law

Federal and state laws governing public education and the legal responsibilities and powers of various state and local governing bodies and individuals. Emphasis given case law, federal and state, affecting such topics as rights of teachers, rights of students, due process, liability, and equal protection.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

EDEL 5054:

Administration of Special-needs Programs

Basic provisions of federal/state laws, policies, and regulations pertaining to special education, vocational education, and other special-needs client groups of the public schools.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

EDEL 5064:

Contemporary Issues in Special Education

Current issues in special education confronting school personnel and the effect of the standards and accountability movement on students with disabilities and special education programs. Impact of diversity, including ability, cultural and environmental diversity, on education programming.

Models, practices and services in spec ed. Pre: Graduate standing

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

EDEL 5074:

Administrative Issues in Special Education Programs

198 Role and responsibilities of administrator, director, or supervisor of

special education at the school district, state, and federal levels. Statutory requirements, fiscal basis, organizational structure, instructional and related services delivery systems will be explored. Relationship of special education programming to general school administration. Pre: Graduate Standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

EDEL 5084:

Legal & Regulatory Issues in Special Education

Current legal and regulatory requirements and procedures related to special education services. Legal and regulatory mandates for the provision of free appropriate public education to children with disabilities. Due process procedures and other procedural safeguards, discipline, curricular accessibility, and application of the least restrictive alternative principle in special education programming. Pre: Graduate standing

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

EDEL 5104:

Fnd Education P-12 Leadership

Educational leadership from an historical perspective. Policy implications for school leaders. School- community relationship. Qualities and skills for school leaders to make intentional, thoughtful, and ethical decisions in their schools. Ethics and integrity expectations in educational leadership. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

EDEL 5114:

Leader and Change in P-12 Educ

Leadership and change theories that impact school improvement efforts; skills, and dispositions needed to change organizational culture; globalization and diversity relative to implementing change in educational leadership in the 21st century. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

EDEL 5134:

Curriculum Leadership in P-12 Education

Examination of curriculum through theory, practice, social forces, politics, diversity, and economics; analysis of contemporary P-12 school curriculum and reflection about the values, beliefs, and assumptions informing curriculum leadership; long-range planning and curriculum assessment. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

EDEL 5144:

Instruction Leadership P-12 Ed

Leadership in instructional practices in P-12 education; effective classroom instructional strategies; classroom observation and assessment models; models of including diversity and technology in instructional practices; leading instructional professional development to increase student learning evaluating pedagogy. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

EDEL 5164:

Research and Assessment for K-12 Educational Leaders

Prepares K-12 educational leaders to use research and assessment data to make appropriate data-driven decisions at classroom, school, and division levels; analysis of data both generated in the school and state- or agency- controlled; best-practices in school improvement. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

EDEL 5604:

Graduate Seminar in Education

Selected topics in administration, counseling, adult and continuing education, research and evaluation, and community college and other domains of higher education. Emphasis is on interactive discourse on topics not typically included in regularly scheduled courses. (Maximum 3C per course).

Credit Hour(s): 1 TO 3

Lecture Hour(s): 1 TO 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

EDEL 5614:

Internship

Student participation in a planned clinical experience under the supervision of a university staff member in an appropriate work center. (Maximum 12C). Consent required.

Credit Hour(s): 1 TO 12

Lecture Hour(s): 1 TO 12

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

EDEL 5974:

Independent Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Independent Study, VI

Instruction Type(s): Independent Study, VI

Prerequisite(s):

Corequisite(s):

EDEL 5984:

Special Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

EDEL 5994:

Research and Thesis

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research

Instruction Type(s): Research

Prerequisite(s):

Corequisite(s):

EDEL 6004:

Theories of Educational Administration

A general course for students of administration in public and private schools, community colleges, four-year colleges, and universities.

Content includes purposes and nature of theory in educational administration and the application of organizational theory to education. Theories of decision making, communication, leadership, climate, power, conflict, change, morale, and motivation are covered.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

EDEL 6014:

Administration of Instructional Programs and Support Services

The roles and responsibilities of central office (system) and building level (school) personnel in the administration of instructional programs and services. Students engage in a variety of activities designed to improve their skills in planning, organizing, delivering, and monitoring instructional programs and services within this dynamic environment. Must have administrative or supervisor certification and experience.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

EDEL 6024:

Public School Budgeting

Policies, principles, and practices involved in the practice of public school budgeting.

Credit Hour(s): 3

200 Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

EDEL 6034:

Planning Educational Facilities

Basic information needed by administrators to mount an effective planning effort within an organization; to plan, develop, and maintain satisfactory buildings to house modern educational programs; to supervise the work of other professionals and technicians in designing and constructing facilities; and to evaluate such efforts. Meets Virginia requirements for placement on the Eligible List of Division Superintendents.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

EDEL 6044:

Governance and Policy in Education

Antecedents of public policy affecting education in the United States, and the relationships between policy making and implementation and educational administration.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

EDEL 6104:

Literature Reviews in K-12 Educational Leadership

Literature reviews in educational leadership and related fields; analysis, critique and synthesis of literature representing research, theory, applicability, and commentary in current topic of interest; preparation of initial literature review; evaluative skills used to identify well-constructed research. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

EDEL 6114:

Applied Qualitative Research in K-12 Educational Leadership

Orientation and approaches to qualitative research. Design and implementation of qualitative research questions and process in K-12 educational leadership. Ethical norms conducting research in the K-12 school setting; responsible use of intellectual property, data collection and reporting, and interactions with human subjects. Observations, interviews, basic data analysis, interpretation and report writing of qualitative research findings.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): EDEL 5164

Corequisite(s):

EDEL 6124:

Advanced K-12 School Law

Influence of school law on PK-12 education; legal issues that pertain to the public schools, including in-depth analysis of accountability, employee relations, and parental and student rights, with emphasis on issues at central office level; rationale for a legally sound environment for students, faculty, and staff; Virginia and national education codes; school system policies and administrative regulations; legal research development. Pre: 5024 or equivalent.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): EDEL 5024

Corequisite(s):

EDEL 6134:

Advanced Topics in Public School Finance

Education policy and practice pertaining to public school finance for educational leaders and policy makers. Equitable distribution of educational monies and resources to achieve desired student outcomes. Linking of availability of sufficient resources with a school divisions ability to educate all students to the highest standards. Pre: EDEL 5034 or equivalent.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

EDEL 6254:**Legal Aspects of Special Education**

Review and analysis of current case law and litigation related to special education. Focus on the legal system that assures children with disabilities free appropriate public education, with emphasis on due process procedures and other procedural safeguards, discipline, program accessibility, and application of the least restrictive alternative principle in special education programming.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

EDEL 6914:**Problems in Education**

Study of contemporary problems in various education settings such as administration, counseling, community college education, and adult and continuing education. (Maximum 3C per course).

Credit Hour(s): 1 TO 3

Lecture Hour(s): 1 TO 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

EDEL 6924:**Professional Seminar**

Critical review, presentation, and discussion of current data-based and issues-related literature, either published or presented at recent national meetings. Provides students an opportunity to amalgamate their prior course experiences to produce a draft dissertation prospectus.

(Maximum 6C credit allowed toward program of study).

Credit Hour(s): 1 TO 6

Lecture Hour(s): 1 TO 6

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

EDEL 7704:**Field Studies in Education**

Advanced applied research and/or evaluation study in one or more educational institutions or agencies. The student is graded on the basis of the design of the study and ability to conduct the study and report the results. (Maximum 12C).

Credit Hour(s): 1 TO 12

Lecture Hour(s): 1 TO 12

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

EDEL 7714:**Internship in Education**

Planned program of advanced clinical practice in education through assignment under direct supervision of outstanding practitioner for periods of up to two semesters. (Maximum 24C).

Credit Hour(s): 1 TO 24

Lecture Hour(s): 1 TO 24

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

EDEL 7994:**Research and Dissertation**

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research

Instruction Type(s): Research

Prerequisite(s):

Corequisite(s):

EDUCATION, EDUCATIONAL RESEARCH, EVALUATION

Serge Hein, Program Director

Emeriti Faculty: Elizabeth Creamer; Kusum Singh;

Professors: Gary Skaggs;

Associate Professors: Serge Hein; Andrew McConney; Yasuo Miyazaki;

Assistant Professors: Fei Gu;

Assistant Professor of Practice: David Kniola;

General Contact: bev@exchange.vt.edu

Graduate Site: <http://www.soe.vt.edu/edre/>

The Educational Research and Evaluation (EDRE) program is a comprehensive Ph.D. program that provides preparation in research methodology as it relates to education, the behavioral sciences, and the social sciences in general. It emphasizes the areas of

evaluation/assessment, measurement, qualitative methods, and statistics, and EDRE students specialize in one of these four areas. Thus, EDRE students have the opportunity to develop methodological expertise in areas that include (a) the development and application of statistical methods in educational and social scientific research, (b) the development and evaluation of psychoeducational instruments, (c) the development and application of qualitative methods in educational and social scientific research, and (d) the development and application of evaluation/assessment methods in educational and social scientific research. To provide EDRE students with a wide range of methodological skills, they also complete a 24 credit hour, core group of research methods courses that include each of the above four areas. The EDRE program requires students to be enrolled full time for two consecutive, regular academic year semesters on the Blacksburg campus. Methodologists specialize in specific research methodologies. Their work normally includes using specific research methodologies to conduct empirical research, conducting research to advance existing research methodologies, and conducting research to develop new, cutting-edge research methodologies. EDRE faculty and students conduct methodological research and applied research on issues in education, the behavioral sciences, and the social sciences in general. The EDRE program was established in 1971 and was the first Ph.D. program in educational research in the State of Virginia. The EDRE program prepares students for careers as research methodologists in a wide range of capacities that include academic positions in education, psychology, or applied statistics; positions in the testing industry (e.g., ETS, ACT, CTB, Pearson); evaluation and assessment positions in higher education; state- or federal-level government positions that involve program evaluation, data analysis, instrument development, and/or survey administration; and positions as private methodological consultants. To be considered for the Ph.D. program in EDRE, applicants must hold a master's degree in a relevant field or discipline, from an accredited college or university, and have a GPA of 3.3 or higher in the degree. Please note that beginning with the Fall 2020 semester, applicants who hold a bachelor's degree in a relevant field or discipline will also be considered for the Ph.D. program in EDRE but will be required to complete additional coursework if admitted. The Ph.D. program in EDRE is only offered on the Blacksburg campus. The Blacksburg campus offers students the full services of the university, including an extensive library system, technological support, and the Graduate Life Center. The EDRE program also offers a 9-credit Graduate Certificate in Educational Research and Evaluation.

SPECIAL FACILITIES

DEGREES OFFERED

PhD Degree

Offered In (Blacksburg)

TOEFL

iBT: (90.0)

GRE

General Test: Verbal, Quantitative, Analytical Writing

The Ph.D. program in EDRE requires a minimum of 90 hours of course work beyond the Bachelor's degree. These hours are divided among Research Methods, Focus Area, Masters/Cognate, and Dissertation Research requirements.

GRADUATE COURSES (EDRE)

EDRE 5404:

Foundations of Educational Research and Evaluation

Research and evaluation in education with emphasis on development of skill requisite for utilizing research and evaluation studies in practical situations. Applies these skills in exercises related to various research and evaluation models.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

EDRE 5644:

Questionnaire Design and Survey Research in Education

This course provides an overview of survey research for graduate students in education. It covers the process from project formulation and sampling, through instrument design and question formulation, to data processing and report writing. Emphasis will be on questionnaire design, providing students with an opportunity to create and revise their own questionnaire and critique instruments used in educational surveys.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): EDRE 5404 (UG) OR EDRE 5404

Corequisite(s):

EDRE 5674:

Introduction to Mixed Methods

Introduction to Mixed Methods research and evaluation in applied social and behavioral sciences, including education, human development, sociology, and medicine. Mixed methods are used to collect and analyze both qualitative and quantitative data.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): EDRE 5404

Corequisite(s):

EDRE 5974:

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Independent Study

Instruction Type(s): Independent Study

Prerequisite(s):

Corequisite(s):

EDRE 5984:

Special Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

EDRE 6504:

Qualitative Methods in Educational Research I

This course provides an introduction to qualitative research methods. It considers mainstream qualitative research traditions, including case study, phenomenology, ethnography, grounded theory, and participatory research. Students will conduct observations, interviews and basic data analysis.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): EDRE 5404

Corequisite(s):

EDRE 6524:

Qualitative Methods in Educational Research II

This course provides an advanced examination of qualitative inquiry in educational and human science research. It considers theoretical assumptions of major qualitative research traditions and provides students advanced skills in data analysis and representation.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): EDRE 6504

Corequisite(s):

EDRE 6534 (EDCI 6534):

Ethnographic Methods in Education

Exploration of ethnographic methods for data collection and analysis; theoretical bases, procedures, issues, and applications of this approach in educational research.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): EDCI 6034

Corequisite(s):

EDRE 6605:

Quantitative Research Methods in Education I & II

This two-course sequence is designed to provide an overview of basic research design, measurement and statistical concepts in social and behavioral research. Emphasis will be placed on understanding the process of social and educational research in field settings, hands on experience of designing and conducting research and analysis of data.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): EDRE 5404 (UG) OR EDRE 5404

Corequisite(s):

EDRE 6606:

Quantitative Research Methods in Education I & II

This two-course sequence is designed to provide an overview of basic research design, measurement and statistical concepts in social and behavioral research. Emphasis will be placed on understanding the process of social and educational research in field settings, hands on experience of designing and conducting research and analysis of data.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): EDRE 6605

Corequisite(s):

EDRE 6624:

Measurement Theory in Education

Methods and theories of estimating and enhancing test score characteristics, particularly reliability and validity of aptitude and achievement tests. Problems associated with test construction, use, and score interpretation will be emphasized.

Credit Hour(s): 3

Lecture Hour(s): 3

204 Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): STAT 5634

Corequisite(s):

EDRE 6634 (STAT 6634):

Advanced Statistics for Education

Multiple regression procedures for analyzing data as applied in educational settings, including curvilinear regressions, dummy variables, multicollinearity, and introduction to path analysis.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

EDRE 6654:

Multivariate Statistics for Applications to Educational Problems

Multivariate statistical procedures presented in an applied research setting. Oriented toward the logical extension of univariate tests of significance and estimation procedures to multivariate problems.

Emphasis on using existing computer software packages.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): (STAT 6634 (UG), EDRE 6634 (UG), STAT 6644 (UG), EDRE 6644 (UG)) OR (STAT 6634, EDRE 6634, STAT 6644, EDRE 6644)

Corequisite(s):

EDRE 6664:

Application of Structural Equations in Education

Applications of structural equation causal models in educational research and discussion of the methodological questions pertaining to such models. Topics include recursive and nonrecursive models, measurement errors in causal models, latent unobserved variables, and covariance structures.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): EDRE 6634

Corequisite(s):

EDRE 6674:

Longitudinal Data Analysis

Formulate research questions. Identify appropriate models for questions.

Selecting, modeling, data analysis, interpretation, and presentation of the advanced methods of Longitudinal Data Analysis (LDA). Growth model in hierarchical linear modeling (HLM) or multilevel modeling; Latent curve models in structural equation modeling (SEM); Econometric fixed effects models. Research report strategies and styles.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): EDRE 6634

Corequisite(s):

EDRE 6684:

Instrument Development and Validation

Provides experiences in developing instruments, or tests, that are designed to measure educational and psychological constructs, such as knowledge, skills, attitudes, and traits. Issues and practices relating to construct specification, instrument design and administration, and analysis and summary of validity study data will be emphasized. Must have EDRE 6606 prerequisite or comparable graduate level statistics course.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): EDRE 6606

Corequisite(s):

EDRE 6694:

Hierarchical Linear Modeling

Provides a conceptual framework of hierarchical linear modeling (HLM), some important statistical theory behind the HLM, and hands-on training for applying HLM technique through analyzing example data sets and projects. The course includes the formulation of statistical models for typical applications such as two-level organizational study, two-level growth model, and three-level growth model within contexts and prepares students to be able to use multilevel analysis to address research questions in their fields and write coherent summaries and interpretations of the results.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): EDRE 6634

Corequisite(s):

EDRE 6704:**Evaluation Methods in Education**

Principles of evaluation with emphasis on practices applicable to a variety of educational settings. The theoretical and philosophical bases which lead to alternative methodologies. Design and measurement alternatives are considered within the jurisdictional, theoretical, and philosophical contexts.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

EDRE 6744:**Mxd Method Research Dsgn**

Provides an introduction to mixed methods research design in the human and behavioral sciences. Students will design and execute a pilot study for a mixed method research project.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture, Online Research

Instruction Type(s): Lecture, Online Lecture, Online Research

Prerequisite(s): EDRE 6606, EDRE 6504

Corequisite(s):

EDRE 6754:**Advanced Item Response Theory**

Provides students with the concepts and skills to carry out Item Response Theory (IRT) analyses using specialized software, and an introduction to research in measurement. Topics will include binary and polytomous models, item and ability parameter estimation, model fit, and scaling and equating.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): EDRE 6624 OR EDRE 6684

Corequisite(s):

EDRE 6784:**Advanced Issues in Qualitative Research**

Provides advanced treatment of important theoretical and methodological topics in the contemporary qualitative literature and in the ongoing development of qualitative methodology. Emphasis is placed on addressing both theoretical issues and issues of research praxis. Topics covered vary from term to term.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): EDRE 6524

Corequisite(s):

EDRE 6794:**Advanced Topics in Educational Research**

Advanced treatment beyond standard courses in topics such as questionnaire design, survey sampling, factor analysis, and meta analysis. May be repeated with different topics for up to 6 hours of credit.

Credit Hour(s): 1 TO 6

Lecture Hour(s): 1 TO 6

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): STAT 5634

Corequisite(s):

EDRE 6974:**Independent Study**

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Independent Study

Instruction Type(s): Independent Study

Prerequisite(s):

Corequisite(s):

EDRE 6984:**Special Study**

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

EDRE 7714:**Internship in Education**

Planned program of advanced clinical practice in education through assignment under direct supervision of outstanding practitioner for periods of up to two semesters. (Maximum 24C).

Credit Hour(s): 1 TO 24

Lecture Hour(s): 1 TO 24

206 Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

EDRE 7964:

Field Studies in Education

Advanced applied research and/or evaluation study in one or more educational institutions or agencies. The student is graded on the basis of the design of the study and ability to conduct the study and report the results. (Maximum 12C).

Credit Hour(s): 1 TO 12

Lecture Hour(s): 1 TO 12

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

EDRE 7994:

Research and Dissertation

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research

Instruction Type(s): Research

Prerequisite(s):

Corequisite(s):

ENGLISH

Rebecca Weaver-Hightower, Chair

Kelly Pender, Associate Chair

Professors: Charlene Eska; Joseph Eska; Virginia Fowler; Thomas Gardner; Kenneth Hodges; Nancy Metz; Su Fang Ng; Katrina Powell; David Radcliffe;

Associate Professors: Katie Carmichael; Sheila Carter-Tod; Gena Chandler-Smith; Anthony Colaianne; James Dubinsky; Shoshana Knapp; Derek Mueller; Kelly Pender; Jennifer Sano-Franchini; Karen Swenson; Abby Walker;

Assistant Professors: Sweta Baniya; Silas Cassinelli; Katharine Cleland; Carolyn Commer; Julie Gerdes; Chris Lindgren; Ashley Reed; Tyechia Thompson; Andrew Wadoski;

Alumni Distinguished Professor: Thomas Gardner;

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Graduate Site: <https://liberalarts.vt.edu/departments-and-schools/department-of-english/academic-programs/master-of-arts-in-english.html>

The Master of Arts Program in English at Virginia Tech is a general master's degree in the study of literature and language. Students explore their own interests in British and American literature through a variety of courses. Some classes are shared with the Masters of Fine Arts students in our Creative Writing program. Some classes are shared with doctoral students in our Rhetoric and Writing program. Students will develop core competencies in British, American, and World Literatures the analysis of texts the writing and development of arguments defining a problem and/or creating a research question the processes of academic research The interdisciplinary nature of English studies enables students to also take classes in other programs such Women's and Gender Studies, Science & Technology Studies, Africana Studies, and History. This cross-disciplinary focus provides students with exposure to various dimensions of English studies. Students then apply that exposure and pursue independent research either as a thesis or capstone project. Students work in a close relationship with our award-winning faculty to develop their thesis or capstone projects toward their unique career and academic goals. Since our program builds core competencies in critical reading, writing, research, and analysis that can be applied in a variety of ways beyond the MA degree, our graduates typically move into a variety of fields including business, law, technology, marketing, design, teaching, and technical writing. More recently, our students move in one of three directions upon completion of their degree: enrollment in a PhD program in literature or writing; high school- or instructor-level teaching; writing or document-related jobs in technical writing. The interdisciplinary nature of English studies allows students to strengthen these core English competencies while developing and shaping a curriculum that speaks to students' individual interests and career goals. Applicants who are interested in our assistantships should apply no later than February 1, 2021. For more information about our Master of Arts degree in English, please consult our website: <https://liberalarts.vt.edu/departments-and-schools/department-of-english/academic-programs/master-of-arts-in-english.html>.

SPECIAL FACILITIES

The 360 Digital Studio at Virginia Tech

The 360 Digital Studio at Virginia Tech is located on the second floor of the English Department (Shanks Hall 360). Students enrolled in any English classes at Virginia Tech may use the 360 Digital Studio to Print Assignments for Classes Work on group projects using any one of the 6 large tv screens and other resources Access professional software (40+) with various design, word processing, and data analysis capabilities For more information about The 360 Digital Studio, consult the following link: https://360digitalstudio.github.io/about_us.html

The Center for Rhetoric in Society

The Center for Rhetoric in Society is located on the third floor of the English Department (Shanks Hall 340 E) on the Virginia Tech campus in Blacksburg, Virginia. The Center's mission involves studying rhetoric and writing in action, with a particular interest in writers and speakers who face rhetorical challenges related to their social positions and

circumstances. We believe, with Jacqueline Jones Royster, that "groups who have honed their crafts at the margins may be the rhetors from whom we can learn and be inspired." We are always looking for new collaborators and graduate assistants. If you have a project that connects with our mission or if you are studying at Virginia Tech and pursuing an advanced degree related to rhetoric, composition, or technical communication, we would be happy to hear from you. Learn more about opportunities to get involved with the center and contact us if you'd like more information at rhetoric@vt.edu or consult our website at <https://www.rhetoric.english.vt.edu/>.

The Linguistics Speech Lab

The Linguistics Speech Lab is housed on the second floor of the English Department (Shanks Hall 254). The Speech Lab is A venue for meetings A place to process linguistic data A place to collect linguistic data (through interviews or experiments) The home of linguistic corpora The home of useful equipment and a mini-library The Lab is available to faculty, undergraduate, and graduate researchers. For more info, please contact Abby Walker at ajwalker@vt.edu or Katie Carmichael at katcarm@vt.edu or consult our website at <http://www.vtlinguistics.com/speech-lab/>.

DEGREES OFFERED

MA Degree

Offered In (Blacksburg)

TOEFL

Paper: (577.0)

Computer: (233.0)

iBT: (90.0)

GRE

General: Verbal, Quantitative, Analytical

The MA in English requires 36 hours of coursework. All students must take two required courses in Literary Research (ENGL 5014) and Critical Theory (ENGL 5024). Students must also take a course on the theory and practice of university writing instruction (currently listed as ENGL 5454 Studies in Theory; alternatively listed as ENGL 5004). Students must also complete a "Capstone" project. The Capstone Project has a thesis (6 credits) and a non-thesis (3 credits) option. Because work in literature and language frequently is interdisciplinary, students are permitted to take six of their credits outside of the department. Students may also work toward a graduate certificate offered by the Virginia Tech Graduate School in a related field. Possible fields include ASPECT (Alliance for Social, Political, and Cultural Thought), Africana Studies, Future Professoriate, Material Culture and Public Humanities, Public History, Race and Social Policy, Religious Studies, Science and Technology Studies, and Women and Gender Studies. <https://liberalarts.vt.edu/departments-and-schools/department-of-english/academic-programs/master-of-arts-in-english.html> TESTING REQUIREMENTS*Currently, the GRE general and subject test are NOT REQUIRED for admission to the Virginia Tech M.A. Program in English.**For International Students*International students seeking

admission must receive a minimum TOEFL score of 90 or an IELTS score of 6.5 for admission. Students must also receive a TOEFL score of 20 or higher in the Listening, Writing, Speaking, and Reading subsections. In addition to these tests, English proficiency can also be demonstrated through a conferred bachelor's degree from an accredited university where English is the medium of instruction. In this instance, the Graduate School will code a waiver of the English proficiency requirement into the student's application. Students can confirm degree conferral and English as the medium of instruction by submitting their official transcripts with the application. For more information about policies and the application process for international students, consult the following links: Testing Requirements Graduate School International Student Resources Direct additional inquiries to Ms. Sally Shupe, Graduate Programs Coordinator, sashupe@vt.edu or 540-231-4659.

GRADUATE COURSES (ENGL)

ENGL 5004:

Theory and Practice in University Writing Instruction

The study of rhetorical theory, related issues in writing pedagogy, and the practice of teaching composition at the university level for GTAs in the Department of English. Pre-requisite: Graduate Standing and appointment as a GTA in the Department of English.

Credit Hour(s): 6

Lecture Hour(s): 4

Instruction Type(s): Lab, Lecture, Online Lecture

Instruction Type(s): Lab, Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ENGL 5014:

Introduction to Literary Research

This course introduces the materials and methods of research used in English studies. Students learn how to locate primary texts, contextual documents, and critical scholarship, to evaluate their kinds and degrees of authority, and to incorporate and cite this material in original research.

Pre: Graduate Standing

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ENGL 5024:

Critical Theory in English Studies

Introduces graduate students to principal issues, concepts, terms, and methods currently employed in literary criticism and the interdisciplinary study of culture. Pre: Graduate Standing

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ENGL 5034:

Practicum

Practical training in teaching composition at the university level.

Required of all Graduate Teaching Assistants in English. Pre: Graduate Standing

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ENGL 5054:

Composition Theory

Study of history and theory of teaching composition at the university-level. Introduction to research methods in Composition Studies. Detailed consideration of the epistemological and cultural implications of writing instruction. Prerequisite: Graduate Standing required

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ENGL 5064:

Topics in Language

Rotating topics in language study, exploring various theories of language and their bearing on literary interpretation, rhetoric, and textual criticism.

Content will vary; may be repeated once for credit. Pre: Graduate Standing

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ENGL 5074:

Introduction to Digital Humanities

This course introduces students to the history and critical theory necessary to understand the broad import of digital technology for English Studies and to the knowledge and skills required to critique and produce digital documents. Must have graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ENGL 5084:

Creative Writing Practicum

Training in teaching introductory creative writing at the university level.

Emphasis is on the theory and practice of teaching creative writing, preparing materials and class sessions, and responding to student writing. Pre-requisite: Graduate Standing in the MFA program in the Department of English and appointment as a GTA.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ENGL 5094:

Collab Research Practicum

Practical training in collaborative research practices in discourse analysis, ethnography, historical investigation and other subjects at the graduate level. Pre: Graduate Standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ENGL 5114:

Studies in Medieval Literature

Rotating studies in medieval literature, focusing on particular themes, genres, works, or figures within their historical, social and literary context. Content will vary; may be repeated for credit. Pre: Graduate Standing

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ENGL 5124:

Studies in Renaissance Literature

Rotating studies in British literature from 1500 to 1660, focusing on literary traditions, themes, or representative writers. May be repeated once for credit. Pre: Graduate Standing

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ENGL 5164:

Studies in Black American Literature

Rotating studies in Black American literature, focusing on its roots in folk and oral traditions; on key periods, such as the Harlem Renaissance; or on themes, genres, or selected figures. Content will vary; may be repeated once for credit. Pre: Graduate Standing

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ENGL 5224:

Studies in Early English Authors

Rotating studies in the works of such early writers as Chaucer, Shakespeare, or Milton, focusing on their relationship to history; on key texts; on themes or genres; or on critical approaches. Content will vary; may be repeated once for credit. Pre: Graduate Standing

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ENGL 5234:

Studies in Later English Authors

Rotating studies in the works of one or two later English writers, such as Dickens, Hardy, Tennyson, Woolf, Joyce, Yeats, and others. Contents will vary; may be repeated once for credit. Pre: Graduate Standing

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ENGL 5244:

Studies in American Authors

Rotating studies which offer intensive treatment of one or two American authors, with particular attention to historical, biographical, cultural, and/or critical and theoretical contexts. Content will vary; may be repeated once for credit. Pre: Graduate Standing

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ENGL 5314:

Genre Studies

Rotating studies of particular genres--lyric, biography, literary criticism, speculative fiction--in relation to their social, intellectual, and literary contexts. Content will vary; may be repeated once for credit. Pre: Graduate Standing

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ENGL 5334:

Special Topics in Literature

Approaches to the study of literature that cross the boundaries of genre, period, and nationality, exploring innovative combinations of texts, critical methods, and interpretive approaches. Contents will vary; may be repeated once for credit. Pre: Graduate Standing

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ENGL 5354:

Rotating studies in global literature and theory, focusing on comparisons of authors, works, periods, or genres of different regions, countries, and/or cultures. Content will vary; may be repeated once for credit. Pre:

Graduate Standing

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ENGL 5454:

Studies in Theory

Rotating studies of the major issues, figures, and movements in literary and critical theory. Content will vary; may be repeated once for credit.

Pre: Graduate Standing

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ENGL 5464:

Introduction to Medical Humanities

Introduction to the medical humanities. Literary inquiry as narrative medicine, medicine and literature, literary bioethics, medical rhetoric, and cultural studies of medicine.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

ENGL 5474:

Teaching Literature

Practices of teaching literature at the college and university level, including close reading, the application of critical theory, the introduction of historical and social contexts, and the making and assessing of writing assignments. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ENGL 5514:

American Literature of the Later Nineteenth Century

American literature from the Civil War to the end of the century, with emphasis on Whitman, Dickinson, Twain, James, and Crane. Pre:

Graduate Standing

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ENGL 5534:

Studies in Literary History

Rotating studies in literary history. Topics, periods, and approaches will vary; may be repeated once for credit. Pre: Graduate Standing

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ENGL 5614:

Visual Rhetoric and Document Design

Examination of the theories, research, and practices of visual rhetoric and document design. Emphasis on ways in which images and other visual methods of communication influence audiences. Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ENGL 5624:

Intercultural Communication

Examination of theoretical and practical issues pertaining to writing and designing for intercultural and/or international audiences. Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Corequisite(s):

ENGL 5654:

Professional Writing Pedagogy

Theoretical and practical aspects of designing and teaching an introductory undergraduate course in technical or business communication in academic or business settings. Students will investigate various methods and materials used to teach written, oral, and visual communication appropriate for such courses. Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ENGL 5664:

Theory & Research in Tech Comm

Key theories, methods, strategies, genres, and modes of written and multimedia technical communication and information design. Intellectual history of the field and its relation to contributing disciplines. Economic, political, cultural, and ethical contexts of technical communication. Pre: Graduate Standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ENGL 5674:

Rhetoric of Science and Technology

Analysis of the historical and philosophical development of the field of rhetoric of science and technology through benchmark publications; examination of scientific texts and technologies as objects of rhetorical criticism. Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ENGL 5734:

Form and Theory of Fiction

A graduate course for writers of fiction in which students are taught to

analyze the forms and theories which underlie the development of the genre. Students will be asked to critique the theoretical assumptions which have been applied to the genre and study the history and conventions that have shaped the writing of fiction. They will be required to interrogate the forms and prevailing theories which have shaped major novelists and short story writers, and apply what they discover to the crafting of their own fiction. Pre: Graduate Standing

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ENGL 5744:

Form and Theory of Poetry

A graduate course for practicing poets and writers in which students are taught to analyze the forms and theories which underlie the development of the genre. Students will be asked to critique the theoretical assumptions which have been applied to the genre and study the history and conventions that have shaped the writing of poetry. Students will analyze prosody; imitate metrical forms, such as the sonnet and the sestina; and adapt the techniques used by poetic masters. Students will study the works of a wide array of writers, from Chaucer to contemporary poets. They will be required to interrogate the forms and prevailing theories which have shaped the voices of poets through the ages. Pre: Graduate Standing

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ENGL 5774:

Editing a Literary Journal

Introduction to the process of editing a literary journal. As editors for the MFA Programs online journal of poetry, fiction, and essays. Developing critical skills as the basis for editorial decisions. Understand the dominant literary aesthetics informing contemporary writing; accept or reject submissions; maintain correspondence with authors; and meet deadlines. May be taken up to three times for a maximum of 9 credits. Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ENGL 5894:

Final Examination

For non-thesis candidates who are required to register for their final examination and have completed their program of study. Not to be included in minimum 33 hours required for degree.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ENGL 5954:

Study Abroad

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ENGL 5974:

Independent Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Independent Study, VI

Instruction Type(s): Independent Study, VI

Prerequisite(s):

Corequisite(s):

ENGL 5984:

Special Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ENGL 5994:

Research and Thesis

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research, Online Research

Instruction Type(s): Research, Online Research

Prerequisite(s):

Corequisite(s):

ENGL 6314:

Classical Rhetoric in Written Communication

Study of major figures and concepts in classical rhetoric, with emphasis on applications to written communication. Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ENGL 6324:

Modern Western Rhetoric

Study of major figures, key concepts, and evolution of modern Western rhetoric. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ENGL 6334:

Rhetoric in Society

Study of the relationship of language and human action, with emphasis on how rhetoric reflects and shapes social practices and how literate activity operates in a complex society; emphasis on written communication. Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ENGL 6344:

Rhetoric in Digital Environments

and sharing, and advocacy regarding public issues. Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ENGL 6364:

Research Design in Rhetoric and Writing

Theory and practice of evaluating, designing, and conducting empirical research projects in rhetoric and writing. Focus on critiquing studies, developing research questions, selecting methods, and designing projects. Introduction to appropriate statistical concepts and methods as well as qualitative and hybrid methodologies. Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ENGL 6374:

Field Methods of Research in Rhetoric and Writing

Examination of field methods and methodology in rhetoric and writing, including case studies, ethnographies, qualitative interviews, and field/participant observations. Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ENGL 6514:

Studies in Rhetoric

Studies in the history, topics, sites of practice, and major figures of rhetoric, with application to written communication and English Studies. May be repeated twice for a total of 9 hours credit when the topic varies. Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ENGL 6524:

Theories of Written Communication

Studies in theories applied to written communication. May be repeated twice for credit for a total of 9 hours when the topic varies. Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ENGL 6704:

Fiction Workshop

This advanced course in fiction writing provides those who wish to pursue careers in creative writing with the tools they need to develop as novelists and short story writers. Primary focus in on the writing and critiquing of original short stories and longer pieces of original fiction, while paying close attention to the work of established fiction writers who are acknowledged masters of their genres. This course may be repeated up to the maximum credit hours (15). Previous workshop experience is required. Pre: Graduate Standing

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ENGL 6714:

Poetry Workshop

This advanced course in poetry writing provides those who wish to pursue careers in creative writing with the tools they need to develop as poets. Primary focus is on the writing and critiquing of original poems, while paying close attention to the work of established poets who are acknowledged masters of their genres. This course may be repeated up to the maximum credit hours (15). Previous workshop experience is required. Pre: Graduate Standing

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ENGL 6724:**Playwriting Workshop**

This advanced course in playwriting provides those who wish to pursue careers in creative writing with the tools they need to develop as playwrights. Primary focus is on the writing and critiquing of original plays, while paying close attention to the work of established dramatists who are acknowledged masters of their genres, and to the aspects of playwriting that relate to theatrical production. This course may be repeated up to the maximum credit hours (15). Previous workshop experience is required. Pre: Graduate Standing

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ENGL 6734:**Creative Nonfiction Workshop**

Advanced course in creative non-fiction writing providing those who wish to pursue careers in creative writing with the tools that they need to develop as essayists and memoirists. Primary focus is on the writing and critiquing of original creative nonfiction, while paying close attention to the work of established creative nonfiction writers who are acknowledged masters of their genres. Course may be taken up to six times for a maximum of 18 hours of credit. Previous workshop experience is required. Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ENGL 6744:**New Media Writing Workshop**

Advanced course in New Media writing that provides students with the knowledge and skills required to develop in this area of creative writing. Primary focus is on the writing and critiquing of original New Media works. Course may be repeated for up to a total of 12 credits. Pre:

Graduate Standing

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ENGL 7994:**Research and Dissertation**

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research, Online Research

Instruction Type(s): Research, Online Research

Prerequisite(s):

Corequisite(s):

FOREIGN LANGUAGES, CULTURES, AND LITERATURES**Professors:** Jacqueline Bixler; Jessica Folkart; Vinodh Venkatesh; Ronda Watson;**Associate Professors:** Catalina Andrango-Walker; Elisabeth Austin; Maria Cana Jimenez; Alexander Dickow; Aarnes Gudmestad; Medoune Gueye; Sharon

Johnson; Corinne Noiro; Richard Shryock; Sarah Sierra; Fabrice Teulon;

Assistant Professors: Javiera Jaque; Gonzalo Montero; Patrick Ridge;**Alumni Distinguished Professor:** Jacqueline Bixler;**Graduate Contact:** jfolkart@vt.edu**Graduate Site:** <https://liberalarts.vt.edu/departments-and-schools/department-of-modern-and-classical-languages-and-literatures.html>

French and/or Spanish. On campus or online. Details at <https://liberalarts.vt.edu/departments-and-schools/department-of-modern-and-classical-languages-and-literatures.html> or contact psaville@vt.edu. The fully accredited Master of Arts in Foreign Languages, Cultures & Literatures at Virginia Tech is designed to meet the needs of students seeking academic and other professional careers in contexts that require intercultural competency as well as a specialized knowledge of Spanish and/or French. Key features: Internationally ranked research university. Fully accredited. Interdisciplinary approach to learning. Coursework includes literature, cultural studies, cinema, visual culture, translation, linguistics and business. Solid foundation in Hispanic, French, and Francophone cultures and literatures. Acquisition and development of analytical abilities based on a range of critical approaches. Preparation for working independently in a variety of settings. Degree may be completed on campus or online. Graduate teaching assistantships available at the Blacksburg campus. Financial aid available. Our graduates pursue various career paths, including the following: Pre-K to 12 education. Teaching at community colleges or universities. NGO and development work. Government agencies. Doctoral education at top-ranked universities, such as Duke, Emory, University of North Carolina at Chapel Hill, Rutgers University, University of Minnesota, University of Virginia, University of Maryland, Washington University in St. Louis, Ohio State University. See <https://liberalarts.vt.edu/departments-and-schools/department-of-modern-and-classical-languages-and-literatures.html> or contact us at psaville@vt.edu.

SPECIAL FACILITIES

The MA in French/Francophone, Hispanic, or Multilingual Studies may be completed at the Blacksburg campus, or online through the Virtual campus. Blacksburg students enjoy physical access to the full services of the university, including an extensive library, technology support, and the Graduate Life Center. Online students access the library electronically and by post. The university provides the specialized software necessary to attend classes online in real time, using the student's own computer, webcam, and headset. Full technical support is provided.

DEGREES OFFERED

MA Degree

Offered In (Blacksburg, Virtual)

TOEFL

Paper: (600.0)

Computer: (250.0)

iBT: (100.0)

Students choose one of three tracks: French and Francophone Studies. Hispanic Studies. Multilingual Studies, combining French and Spanish. Within each track, students will take a combination of required core courses and electives. In addition to coursework, students either write a thesis or take a comprehensive examination based on a reading list. Students enrolled full time usually complete all degree requirements within two academic years. Time to degree varies for part-time students. For details see <https://liberalarts.vt.edu/departments-and-schools/department-of-modern-and-classical-languages-and-literatures.html> or contact us at psaville@vt.edu.

HISTORY

Brett Shadle, Chair

Professors: Mark Barrow; Arthur Ekirch; Edward Ewing; Richard Hirsh; Brett Shadle; Peter Wallenstein;

Associate Professors: Glenn Bugh; Beverly Bunch-Lyons; Heather Gumbert; Matthew Heaton; Kathleen Jones; Marian Mollin; Amy Nelson; Paul Quigley; Helen Schneider; Neil Shumsky; Robert Stephens; Daniel Thorp;

Assistant Professors: Danna Agmon; Amanda Demmer; Carmen Gitre; Edward Gitre; Dennis Halpin; Lucien Holness; Melanie Kiechle; Allan Lumba; Edward Polanco; Jessica Taylor; LaDale Winling;

Robertson Professor of Civil War Studies: Paul Quigley;

Graduate Contact: mheaton@vt.edu

Graduate Site: <https://liberalarts.vt.edu/departments-and-schools/department-of-history/academic-programs.html#graduate>

The Master of Arts program in History provides talented students with

advanced training in the professional practice of historical research and pedagogy. The program serves three primary constituencies: students preparing for further graduate work at the doctoral level, those who wish to become secondary school educators, and those planning for careers in a range of public history fields (the program offers a specialized Graduate Certificate in Public History). By preparing broadly-trained practitioners who have research expertise in a chosen field of specialization, the MA in History also offers an excellent foundation for careers in public relations, journalism, law, and public service. Quite apart from its vocational promise, History is a foundational discipline in the humanities, and the serious study of the past is a source of intellectual enrichment and a lifelong endeavor. Applicants requesting a graduate assistantship should apply by February 1. The program also offers scholarships for students interested in Civil War studies through the Virginia Center for Civil War Studies. For more information about the graduate program and the application process, please consult our website: <https://liberalarts.vt.edu/departments-and-schools/department-of-history/academic-programs/master-of-arts-in-history.html>

SPECIAL FACILITIES

The History Department is located on the 4th floor of Major Williams Hall.

DEGREES OFFERED

MA Degree

Offered In (Blacksburg)

TOEFL

Paper: (600.0)

Computer: (250.0)

iBT: (100.0)

GRE

General Test: Verbal (158.0), Quantitative, Analytical (4.5)

The department offers a Master of Arts in History and a Master of Arts in History and Area Studies (an interdisciplinary program with the Department of Foreign Languages and Literatures). Both degrees require a minimum of 33 credit hours of coursework. Because research and writing are fundamental tenets of the discipline of history, students are expected to complete a major original research project as part of their plan of study. Most students complete this requirement by designing, researching, and writing a thesis. Students who choose the non-thesis option take additional coursework and submit a research paper to complete research requirements. For more information about policies and degree requirements contact mheaton@vt.edu.

GRADUATE COURSES (HIST)

HIST 5104:

Historical Methods

Introduction to the theoretical frameworks and historiographical debates that inform the contemporary research and writing of history. Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

HIST 5114:

U.S. to 1877

American history, from European discovery through Reconstruction. Emphasis on major themes and developments in the emergence of the United States: exploration and settlement; encounters among Europeans, Africans, and Native Americans; achievement of political independence; territorial expansion and political conflict; immigration, industrialization, and urbanization; Civil War, emancipation, and Reconstruction.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

HIST 5124:

U.S. Since 1877

Introduction to main themes in U.S. history beginning with post-Civil War industrialization. An intensive readings course emphasizing the social, cultural, political, economic and military changes in the century after Reconstruction.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

HIST 5134:

Research Methods for Historians

Introduction to skills and methods used in the research, writing and publication of historical scholarship.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): HIST 5104

Corequisite(s):

HIST 5154:

Writing Skills for the Professional Historian

Writing skills for clear, professional historical writing. Narrative approaches to writing public history, conference presentations, and scholarly publications. Methods of incorporating feedback. Self-editing skills. Pre: Graduate standing.

Credit Hour(s): 2

Lecture Hour(s): 2

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

HIST 5205 (STS 5205):

Main Themes in the History of Science and Technology

Methods and concepts in the history of science and technology. 5205: research methods, interpretive approaches, and contemporary issues in the history of science; 5206: research methods, interpretive approaches, and contemporary issues in the history of technology.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

HIST 5206 (STS 5206):

Main Themes in the History of Science and Technology

Methods and concepts in the history of science and technology. 5205: research methods, interpretive approaches, and contemporary issues in the history of science; 5206: research methods, interpretive approaches, and contemporary issues in the history of technology.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

HIST 5214 (ASPT 5214):

Topics in Global History

A variable content course exploring historiographical approaches to the study of global history from the classical age to the present. Special emphasis on chronological frameworks, histories and theories of globalization, and implications of new scholarship in global history for research and teaching. May be taken with different content for a total of 6 credit hours. Graduate standing required.

Credit Hour(s): 3

217 Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

HIST 5224:

Readings in African History

Variable topics readings course focusing on historiographical trends on particular themes in African history. May be taken with different content for a total of 6 credit hours. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

HIST 5414 (ASPT 5414):

Topics In Cultural History and Theory

A variable content course exploring the intersection of cultural theory and the discipline of history. Introduces important theoretical contributions to the study of culture and examines how historians have used these constructs to interpret the past. May be taken with different content for a total of 6 credit hours. Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

HIST 5424:

Public History

Introduction to the theoretical, interpretive, controversial, and practical issues facing public historians. Focus on interpretations and specific issues surrounding the presentation of history in museum exhibits, documentary films, photographic collections, community history projects, the Internet, and a variety of other public venues. Prerequisite: Graduate Standing required

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

HIST 5434:

Oral History Methods

Theory and methodology of oral history methods. Use of oral history interviews in historical research, questions of ethics, interpretation, and the construction of memory. Technical operations and a variety of interview techniques, transcription, and historical use of interviews. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

HIST 5444:

Digital History Methods

Methods for researching and presenting history in a digital environment, with special emphasis on use of digital media as a tool for public historians. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

HIST 5454:

Topics in Public History

Current methodological issues facing public history professionals, the intellectual foundations of these issues, and changing standards of practice in the field of public history to engage students in practical, experiential projects in public history. May be taken for a maximum of 6 credit hours. Pre: Graduate standing.

Credit Hour(s): 3 TO 6

Lecture Hour(s): 3 TO 6

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

HIST 5484 (PSCI 5484) (GIA 5484):

Contemporary American Foreign Policy

Covers U.S. foreign policy during the Cold War, the stalemate with the Soviet Union, armament and arms control, containment and deterrence, detente and Reaganism, and the end of the Cold War. Briefly covers events from 1989 to the present. Designed for students with an interest in foreign policy and the global affairs. Prereqs or instructors permission.

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): PSCI 5214, PSCI 5444

Corequisite(s):

HIST 5534:

Imperialism, Nationalism, and Decolonization

Imperialism, nationalism and their legacies in the twentieth century.

Concentration on imperialism and nationalism as categories of historical analysis. Critical examination of the imperial and colonial experiences and of the expansion and transformation of the nation-state system as a consequence of decolonization and global restructuring.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

HIST 5544 (GIA 5614) (PSCI 5614):

Understanding The Israeli Palestinian Conflict

Dynamics of the Israeli-Palestinian conflict. Critical issues that underlie the conflict and divide Israel and the Palestinians. Diplomatic efforts aimed at resolving the conflict. Pre: Graduate Standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

HIST 5624:

Jacksonian America and the Civil War

This graduate seminar focuses first on the social, economic, and political events which led to civil war, and then on various aspects of the war itself. Special emphasis also will be placed on the major political and military leaders of the period.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

HIST 5694:

Amer Environ Hist

Examination of the important ways Americans have shaped and been shaped by the natural environment from the time of European contact with the New World to the present. Emphasis on the evolution of environmental concern in the nineteenth and twentieth centuries.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

HIST 5894:

Final Examination

NONE

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

HIST 5904:

Project and Report

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research, Online Research

Instruction Type(s): Research, Online Research

Prerequisite(s):

Corequisite(s):

HIST 5934:

Gender in U.S. History

Theoretical approaches to understanding the role of gender in political, economic and social life and in popular culture. Survey of major themes and developments since the seventeenth century. Concentration on the development of biological and sociological explanations of gender differences and similarities, and on the evolution of gendered politics and work and family relationships. Emphasis given to class, race, ethnic differences and differences in sexual orientation.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

HIST 5964:**Field Work/Practicum**

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

HIST 5974:**Independent Study**

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Independent Study, VI

Instruction Type(s): Independent Study, VI

Prerequisite(s):

Corequisite(s):

HIST 5984:**Special Study**

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

HIST 5994:**Research and Thesis**

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research, Online Research

Instruction Type(s): Research, Online Research

Prerequisite(s):

Corequisite(s):

HUMAN DEVELOPMENT

April Few-Demo, Head

Professors: Joyce Arditti; April Few-Demo; Karen Roberto; Laura Sands; Jyoti Savla; Cynthia Smith; Pamela Teaster;

Associate Professors: Megan Dolbin-MacNab; Erika Grafsky; Kee Kim;

Assistant Professors: Koeun Choi; Caroline Hornburg; Jeffrey Jackson; Benjamin Katz; Ashley Landers; Jody Russon; Caroline Sanner; Carolyn Shivers; Rose Wesche;

Research Scientists: Isabel Bradburn;

University Distinguished Professor: Karen Roberto;

Assistant Professor of Practice: Jenene Case Pease;

Graduate Contact: aweav32@vt.edu

Department Website: <http://www.hdfs.vt.edu>

All graduate programs in the Department of Human Development and Family Science integrate research-based knowledge with human-based values. We promote the quality of life of our society's most basic elements - individuals, families, and communities. We value collaboration, inclusion, equity, empowerment, passion, and celebration in our work. We also embody a lived commitment to the land grant mission of integrating teaching, research, and outreach.

SPECIAL FACILITIES

Students have opportunities to apply knowledge in real-world settings. The Blacksburg campus is home to three such settings: The Child Development Center for Learning and Research, Adult Day Services, and the Family Therapy Center. The Falls Church campus is home to the Center for Family Services. Graduate students complete course work, internships, practicum, and assistantships related to research, teaching, and outreach at these centers.

Locations, Goals, Specific Research Areas

Locations: Blacksburg The Department of Human Development and Family Science offers programs leading to a master's (M.S.) or doctoral degree (Ph.D.) in Human Development with emphases on childhood and adolescence development (CAD), adult development and aging (ADA), family studies (FS), and marriage and family therapy (MFT). Goals of Facilities and Resources Programs in the Department of Human Development and Family Science integrate research-based knowledge with human-based values. We promote the quality of life of our society's most basic elements - individuals, families, and communities. We value collaboration, inclusion, equity, empowerment, passion, and celebration in our work. We also embody a lived commitment to the land grant mission of integrating teaching, research, and outreach. Distinctive features of our graduate programs include: A commitment to the highest standard of relevance-research, teaching, and outreach that meets real needs of real people; A faculty that is both nationally known and committed to nurturing the best in our students; Opportunities to work closely with faculty and peers on research, journal articles, and professional presentations; Opportunities to apply knowledge in real-world settings. Specific Research Areas Students have opportunities to gain valuable research training working with Human Development and Family Science faculty. A total of 18 areas of research interests are

shared among the doctoral faculty including: Adolescence and emerging adulthood Attachment across the lifespan Clinical practice & supervision Cultural diversity Early childhood and intervention Evaluation research Family & couple dynamics Family diversity, LGBTQ, feminism Family dynamics & parenting Gender relations Gerontology & aging studies Health Intergenerational International studies Qualitative methodology Quantitative statistical methodology Sexuality across the life course Social & cultural systems

DEGREES OFFERED

MS Degree

Offered In (National Capital Region)

TOEFL

Paper: (550.0)

Computer: (213.0)

iBT: (80.0)

GRE

General Test: Verbal (151.0), Quantitative (153.0)

The Master's degree program in Marriage and Family Therapy at the National Capital Region campus requires 51-54 credits. The post-master's certificate in Marriage and Family Therapy at the National Capital campus requires 21 credits. We are not currently enrolling new students in this program.

PhD Degree

Offered In (Blacksburg)

TOEFL

Paper: (550.0)

Computer: (213.0)

iBT: (80.0)

GRE

General Test: Verbal (151.0), Quantitative (153.0)

The Ph.D. in program areas in Adult Development and Aging (ADA), Child and Adolescent Development (CAD), and Family Studies (FS) at the Blacksburg campus admit students who hold either bachelor's or master's degrees. Bachelor's level students complete the master's thesis and degree en route to the Ph.D. Master's level students can receive transfer credit for related graduate courses. The Marriage and Family Therapy Ph.D. program area at the Blacksburg campus admits students with a master's degree. Students complete a minimum of three years of coursework and one year of internship. Along with required courses, doctoral students participate on research teams, engage in teaching mentorship, and complete a dissertation.

GRADUATE COURSES (HD)

HD 5005:

Theories in Human Development and Family Science

HD 5005: Individual development and lifespan theories of human development, theory synthesis and construction, application to research.

HD 5006: Family, community, and macro systems theories across the lifecourse, theory synthesis and construction, application to research.

Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

HD 5006:

Theories in Human Development and Family Science

HD 5005: Individual development and lifespan theories of human development, theory synthesis and construction, application to research.

HD 5006: Family, community, and macro systems theories across the lifecourse, theory synthesis and construction, application to research.

Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

HD 5104:

Adult Development and Aging

Theory and research pertaining to biological/health/daily functioning, cognition, personality, emotional development, and social functioning in the context of diverse families across the life course and life span.

Critical life events and supportive environments, policies, and programs.

Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

HD 5114:

Adult Development and Aging II: Interpersonal Issues

Interpersonal and social development across the adult phases of the life cycle. Integration of theory and research as it pertains to family and friend networks, living arrangements, diverse family forms, and critical

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): HD 5104

Corequisite(s):

HD 5224:

Child Development in the Family Context

Theories of neurobiological, cognitive, emotional, social development, birth to adolescence, in context of families. Critical evaluation, theories and research methods. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

HD 5234:

Cognitive Development: Infancy Through Adolescence

Socio-cultural theories, research methods, and empirical issues in cognitive development from infancy through adolescence. Cognitive processes, social cognition, communication, emotion, learners and learning in various social and cultural contexts. Pre: Graduate Standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

HD 5244:

Sexual Health and Human Rights

Sexual and reproductive health from human development, public health, and critical feminist perspectives, with special attention to human rights issues. Sexually transmitted infections; HIV/AIDS; unintended pregnancy; population policies; eugenics; sexual and reproductive rights; positive sexuality, sex education; and health promotion. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

HD 5254 (PHS 5254):

Social Epidemiology and Health Inequities

Social determinants of health through the life-course. Relationship of social injustice to public health. Interplay of major social factors such as poverty, race and gender to influence health domestically and globally. Application of social epidemiology to a range of health outcomes. Inform effective solutions to health inequities. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

HD 5324:

Marriage and Family Relationships

Theories in family science research. Family demographics and values. Intimate relationships. Sexuality and gender diversity. Race, ethnic, and social class diversity among families; intersectionality. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

HD 5344:

Perspectives On Human Sexuality

Interdisciplinary historical consideration of writings, research, theory, and application of knowledge related to human sexuality.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

HD 5404:

Systems Theory and Family Therapy

Theory development and basic underlying assumptions of a systems framework to marriage and family therapy. Emphasis is on conceptualizing human problems as they are related to the functioning of systems.

Credit Hour(s): 3

Lecture Hour(s): 3

222 Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

HD 5424 (EDCO 5424):

Life Span Human Development

Stages of individual development as they occur in the context of the family life course. Overview of current developmental theories. Impact of race, gender, and class on cultural views of developmental norms.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

HD 5434:

Clinical Marriage and Family Therapy I

Underlying philosophy, theory and practice of the Structural and Strategic approaches to marital and family therapy.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): HD 5404

Corequisite(s):

HD 5444:

Clinical Marriage and Family Therapy II

This course comprises three distinct parts. The first part examines the approaches to family therapy that have been labeled Constructivist Approaches. The second part examines Emotionally Focused Therapy. The final part involves an in-depth look at the Metaframeworks Model developed at the Institute for Juvenile Research in Chicago, which integrates various schools of marriage and family therapy.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): HD 5404

Corequisite(s):

HD 5454:

Clinical Marriage and Family Therapy III

Emphasis is on interrelationships between mind, body, environment, and social aspects of behavior in the context of the family system. The focus will be on the process of diagnosis and treatment in the family context.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): HD 5404, HD 5434, HD 5444

Corequisite(s):

HD 5474:

Professional Seminar In Marriage and Family Therapy

Focuses on the major ethical, legal, and professional issues faced by those in the field of marriage and family therapy.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

HD 5484:

Clinical Marriage and Family Therapy IV

Issues of treatment related to specialized content areas of family therapy. Focus on topics such as: sexual dysfunction, divorce counseling and mediation, the abusive/violent family, addicted family members, suicidal problems, ethical and professional issues in treating marriages and families.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): HD 5434, HD 5444

Corequisite(s):

HD 5514:

Research Methods

Introductory course in research methodology for the social sciences: formulation of a research problem, design, sampling, data collection, measurement, data analysis, interpretation, and writing the research report.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

HD 5524:

223 **Qualitative Methods in HDFS**

Design, conduct, and evaluate qualitative research concerning human development and families. Examines diverse traditions of qualitative research and methods of data collection, interpretation, analysis, and representation, and ethical and practical complexities. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

HD 5614:

Human Development Theory: Literature and Applications

Introduction to major theories of human development and application of these theories to understanding and improving the well being of children, adults, couples, and families within complex social systems. Portfolio project: Preparation of a theoretically driven literature review.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

HD 5624:

Professional Practices in Human Development

Interdisciplinary approaches to professional practices in the delivery of human services. Emphasis on human service delivery to families and communities, management practices, and professional development. Portfolio project: Professional management and leadership assessment.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

HD 5644 (PHS 5644):

Program Development and Evaluation in Human Development

Methods of conducting program evaluations for prevention and intervention programs that promote public health and human development. Major dimensions of evaluation strategies, including process evaluation, impact assessment, and cost analysis. Pre:

Graduate Standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): HD 5614, HD 5624, EDRE 5404

Corequisite(s):

HD 5654:

Grant Development and Administration in Human Development

Overview of the methods and procedures for developing competitive grant proposals. Students learn basic grant writing skills that include identifying and seeking funding sources, preparing a fundable grant proposal, building a budget, and managing a funded project. Portfolio project: Development of actual grant proposal for an organization or special project.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): HD 5614, HD 5624, EDRE 5404

Corequisite(s):

HD 5664:

Internship in Human Development

Provides consultation and seminar dialogue for advanced masters student in Human Development as they undertake experiences in a supervised field setting. Possible settings span an array of human development agencies focused on children, adults, and families. Experiences include activities of a regularly employed professional in the setting accompanied by periodic seminar meetings.

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): HD 5634, HD 5644, HD 5654, EDRE 5404

Corequisite(s):

HD 5714:

Current Topics in Human Development

Advanced seminar on current topics in human development. May be repeated with different topic content for a maximum of 9 credits. Prerequisite: Graduate Standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

HD 5724:**Couples Therapy**

Overview of the conceptual, clinical, and empirical advances in couples therapy. Focus of course will be on using current research on couple interaction and evidence-based marital therapy to assess and treat couples.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): HD 5404

Corequisite(s):

HD 5734:**Marriage and Family Therapy Techniques**

This course introduces the student to the requisite skills for beginning practicum. Students will examine the role of theory in practice, the differences between process and content, the use of process in clinical work, and the impact of gender, ethnicity, and therapists self perception on the therapy process. The course will also review nuts and bolts of therapy (i.e., writing appropriate clinical notes, identifying risk issues, etc.). Admission to the MFT Clinical Program is required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): HD 5404, HD 5434

Corequisite(s):

HD 5744:**Special Topics in MFT**

In-depth study of selected topics in marriage and family therapy (e.g., medical family therapy, play therapy, spirituality and family therapy). Focus of course will be on reviewing current research on the specific issue and developing treatment strategies for individuals, couples, and families. May be repeated for credit with different content for a maximum of 9 credit hours. For Northern Virginia Students Only.

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): HD 5404

Corequisite(s):

HD 5894:**Final Examination**

NONE

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

HD 5964:**Practicum**

Practicum experiences in departmental options under supervision. (Maximum 15 percent of students graduate program). Repeatable with different topics.

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

HD 5974:**Independent Study**

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Independent Study, VI

Instruction Type(s): Independent Study, VI

Prerequisite(s):

Corequisite(s):

HD 5984:**Special Study**

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

HD 5994:**Research And Thesis**

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research, Online Research

Instruction Type(s): Research, Online Research

Corequisite(s):

HD 6004:

Prof Development Seminar

Review and critique of professional issues in the field of human development related to research and scholarship, pedagogy, outreach, and service. May be repeated.

Credit Hour(s): 1

Lecture Hour(s): 1

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

HD 6014:

Theory Construction in Human Development

Concepts, principles, and processes of theory construction; paradigms in human development and family studies; development of definitions; assumptions; propositions, and hypotheses; criteria for evaluating theory; and construction of theoretical statements. The pre-requisite EDRE 6605 may be substituted for an equivalent course in research methods and statistics.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): HD 5614, EDRE 6605

Corequisite(s):

HD 6214:

Parent-Child Interaction

Review of theories and research in parent-child interaction from birth through adolescence and exploration of practical application in various settings.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

HD 6324:

Process In Relationships

Advanced course on process in adult relationships with focus on properties, types, diversity, development, and maintenance of close relationships between adults.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): HD 5324

Corequisite(s):

HD 6404:

Advanced Systems Theory & Family Therapy

Advanced investigation of the development and conceptual basis of systems theory with application to marriage and family therapy.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

HD 6414:

Advanced Traditional Models In Marriage and Family Therapy

Advanced study and application of Systemic, Bowenian, and Narrative family therapy models within the profession of marriage and family therapy. Prior training in general systems theory, family therapy theories, and therapeutic experience in family therapy required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): HD 6404

Corequisite(s):

HD 6444:

Advanced Contemporary Marriage and Family Therapy

Advanced study of the profession of marriage and family therapy. This course will rotate topics and cover two advanced practice areas such as feminist therapy, sex therapy, or therapy with families with substance abuse or violence.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): HD 6414, HD 6424, HD 6404

Corequisite(s):

HD 6464:

Clinical Supervision of Marriage and Family Therapy

Underlying philosophy, theory, and principles of the process of supervising the practice of marriage and family therapy.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): HD 6404, HD 6414, HD 6424

Corequisite(s):

HD 6474:

Advanced Professional Seminar In Marriage and Family Therapy

Advanced understanding of the major ethical, legal, and professional issues faced by those in the field of marriage and family therapy.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

HD 6484:

Marriage and Family Therapy Research

Comprehensive overview of the major empirical research of marriage and family therapy. Prior training in family therapy theories and therapeutic processes required. A basic knowledge of quantitative and qualitative research methods required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

HD 6514:

Adv Research Methods

Advanced level research methodology; examination of current procedures for studying individual development and family relationships.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): HD 5514

Corequisite(s):

HD 6524:

Current Topics in Advanced Research Methods

Discussions on emergent techniques used in contemporary methodological literature. Training in modern software for implementation of complex research methodologies. May be repeated

with different topic content for a maximum of 4 credits. Pre: Graduate standing.

Credit Hour(s): 1 TO 4

Lecture Hour(s): 1 TO 4

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

HD 7994:

Research And Dissertation

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research, Online Research

Instruction Type(s): Research, Online Research

Prerequisite(s):

Corequisite(s):

PHILOSOPHY

Douglas Lind, Head

Emeriti Faculty: Richard Burian; Deborah Mayo;

Professors: James Klagge; Douglas Lind; Lydia Patton; Joseph Pitt;

Associate Professors: Benjamin Jantzen; Michael Moehler; Kelly Trogdon;

Assistant Professors: Ashley Heflin; Gil Hersch; Karen Kovaka; Jordan MacKenzie;

Visiting Faculty: Gregory Novack; Ted Parent;

Graduate Contact: tzapata@vt.edu

General Contact: hollymb2@vt.edu

Graduate Program Director: trogdon@vt.edu

Graduate Site: <https://liberalarts.vt.edu/departments-and-schools/department-of-philosophy/academic-programs/masters-in-philosophy.html>

Placement Record: <https://liberalarts.vt.edu/departments-and-schools/department-of-philosophy/academic-programs/masters-in-philosophy/placement.html>

The Department of Philosophy's M.A. program is one of the top terminal M.A. programs in philosophy in the United States. We offer core graduate training in philosophy in the broadly analytic tradition, with particular strengths in the history and philosophy of science and in ethics, social and political philosophy. Many of our students enter with the intention of enriching their philosophical background and then going on to Ph.D. studies elsewhere. We have been highly successful in placing our students in leading doctoral programs. Other students simply wish to gain a deeper knowledge of philosophy before going on to other

disciplines or professions. In addition to the philosophy M.A., we participate in Ph.D. programs in Science, Technology and Society (which has a philosophy track), and in the Alliance for Social, Political, Ethical, and Cultural Thought.

SPECIAL FACILITIES

The Department of Philosophy has office space for all who are currently enrolled. There is also a conference room (WM 215) for faculty/graduate student use. The Department has a seminar room (MW 225) where most graduate seminars are held.

Philosophy Facilities

The Department of Philosophy has office space for all graduate students who are currently enrolled.

DEGREES OFFERED

MA Degree

Offered In (Blacksburg)

TOEFL

Paper: (550.0)

Computer: (213.0)

iBT: (80.0)

GRE

General Test: Verbal, Quantitative, Analytical

The M.A. degree requires a minimum of 30 credit hours of graduate level work. Students may complete the requirements for the M.A. degree through either the thesis or non-thesis tracks. Students pursuing the thesis track write a thesis and take at least 24 hours of regular coursework. Students pursuing the non-thesis track take at least 27 hours of regular coursework and complete a set of comprehensive exams at the conclusion of the two year program.

GRADUATE COURSES (PHIL)

PHIL 5204:

Topics in the History of Philosophy

An advanced course focusing on particular topics in the history of philosophy. Special emphasis will be placed on ideas and disputes which were historically influential and continue to be philosophically significant. Consent required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PHIL 5204G:

Intermediate Philosophy of Mind

Current issues in the philosophy of mind, such as relation of mind and body, status of the mental, knowledge of one's own and other minds, personal identity, consciousness, mentality of animals and machines, topics in the philosophy of psychology. Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PHIL 5214G:

Intermediate Metaphysics

Examination of central problems of metaphysics. Topics may include: existence, necessary truth, the problem of universals, causation, the identity of the self through time, free will. Attention will be given both to the historical development of these problems and to contemporary philosophical responses to them. Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PHIL 5224G:

Intermediate Epistemology

Theory of knowledge. Exploration of topics including the foundations (or lack of foundations) of knowledge, the role of experience in knowledge, whether knowledge of the present and the nearby gives us reasons for beliefs about the future, the past, or about events far away, and related issues. Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PHIL 5305:

Main Themes in the Philosophy of Modern Science and Technology

Problems, literature, and schools in the philosophy of science and technology. 5305: explanation and confirmation; 5306: theory change.

Credit Hour(s): 3

Lecture Hour(s): 3

228 Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): PHIL 3505

Corequisite(s):

PHIL 5306 (STS 5306):

Main Themes in the Philosophy of Modern Science and Technology

Problems, literature, and schools in the philosophy of science and technology. 5305: explanation and confirmation; 5306: theory change.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

PHIL 5324:

Metaethics

A systematic examination of metaethics, the branch of philosophical ethics that addresses questions about the nature of ethical discourse and its objects. Investigation of such issues as the meaning of ethical terms and judgments, the nature and grounds of ethical truth, the possibility of ethical knowledge, the rationality of ethical behavior, and the relations between ethical and scientific inquiry. Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PHIL 5344:

History of Ethics

Examination of the work of selected figures representative of important positions in the history of ethical theory from the Classical Age to the modern period.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PHIL 5505:

Symbolic Logic

Modern deductive symbolic logic and its metatheory. 5505: Development of a system of first order logic. Truth functional sentential logic, monadic

predicate calculus with identity. Proof techniques and translation between natural and artificial languages. 5506: Logical metatheory: consistency, completeness, and decidability of logical systems.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PHIL 5506:

Symbolic Logic

Modern deductive symbolic logic and its metatheory. 5505: Development of a system of first order logic. Truth functional sentential logic, monadic predicate calculus with identity. Proof techniques and translation between natural and artificial languages. 5506: Logical metatheory: consistency, completeness, and decidability of logical systems.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PHIL 5604G:

Intermediate Philosophy of Biology

This course is designed primarily for philosophy students with a strong interest in biology or biology students with philosophical interests. Topics vary from year to year, but include the changing character of biology as a science, the special character of biological explanations and methods, and the place and value of reduction (e.g., of Mendelian to molecular genetics) in biology. Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PHIL 5614G:

Intermediate Philosophy of Science

An examination of the structure and methodology of science as well as key concepts such as explanation, confirmation, realism, and instrumentalism. Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PHIL 5904:

Project And Report

Only for students pursuing a Master of Arts degree with a non-thesis option. Variable credit course.

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research

Instruction Type(s): Research

Prerequisite(s):

Corequisite(s):

PHIL 5974:

Independent Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Independent Study, VI

Instruction Type(s): Independent Study, VI

Prerequisite(s):

Corequisite(s):

PHIL 5984:

Special Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PHIL 5994:

Research and Thesis

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research

Instruction Type(s): Research

Prerequisite(s):

Corequisite(s):

PHIL 6014:

Special Topics in Philosophy

Close examination of a discipline, topic, or group of questions from a major philosophical tradition. Such areas as philosophy of language, philosophy of logic, and philosophy of mathematics, and such issues as causation, the nature of space and time, mental representation, logical positivism, and the linguistic turn will be examined. May be repeated for credit, with permission and different content, for a maximum of 12 hours. Completion of at least one of the philosophy M.A. core courses required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PHIL 6204:

Advanced Topics in the History of Philosophy

Intensive study of a particular figure, school, or group in the history of philosophy, in cultural and theoretical context, such as Socrates in the Athenian polis, Stoicism in the Hellenistic age, or Hume and the Scottish Enlightenment. May be repeated for credit, with permission and different content, for a maximum of 12 hours. Completion of at least one of the philosophy M.A. core courses required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PHIL 6224:

Distributive Justice

Influential contemporary theories of distributive justice. Social, political, ethical, and cultural dimensions of distributive questions. Utilitarianism, liberalism, libertarianism, pluralism, multiculturalism, autonomy, rights, needs, (global) egalitarianism, and (global) poverty. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PHIL 6314:

History of the Philosophy of Science

the historical development of views about the methods of induction and hypothesis and accounts of theory testing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

PHIL 6324:

Advanced Topics in Ethics and Political Philosophy

A seminar closely examining a topic or group of topics in moral, social, or political theory. Such issues as the foundations of ethics, practical reason, the concept of virtue, political obligation, the bounds of moral and political community, paternalism, liberty, and privacy will be explored. Views considered may include moral realism and antirealism, contractarianism, egalitarianism, libertarianism, and communitarianism. May be repeated for credit, with permission and different content, for a maximum of 12 hours.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): PHIL 5334 OR PHIL 5344

Corequisite(s):

PHIL 6334:

Advanced Topics in Philosophy of Science

Variable topics in advanced philosophy of science, including major theories of scientific explanation and their criticisms; philosophical foundations of statistics; naturalized philosophy of science. May be repeated for credit, with permission and different content, for a maximum of 12 hours.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

POLITICAL SCIENCE

Timothy Luke, Chair

Emeriti Faculty: Richard Rich; Richard Shingles; Charles Taylor; Charles Walcott;

Professors: Francois Debrix; Karen Hult; Farida Jalalzai; Bettina Koch; Ilija Luciak;

Timothy Luke; Ioannis Stivachtis; Edward Weisband; Laura Zanotti;

Associate Professors: Clair Apodaca; Priya Dixit; Deborah Milly; Wayne Moore; Scott Nelson; Besnik Pula; Andrew Scerri;

Assistant Professors: Paul Avey; Binio Binev; Aaron Brantly; Mauro Caraccioli; Cara Daggett; Lillian Frost; Bikrum Gill; Nicholas Goedert; Eric Jardine; Caitlin Jewitt; Karin Kitchens; Jennifer Lawrence; Desiree Poets; Audrey Reeves;

Adjunct Professors: Arnold Dupuy; Adam Newmark; Luke Plotica; Lacha Tchantouridze;

Affiliated Faculty: Laura Jensen; Joel Peters; Patrick Roberts; Gerard Toal;

University Distinguished Professor: Timothy Luke;

Edward S. Diggs Endowed Chair in the Social Sciences: Edward Weisband;

Collegiate Assistant Professors: Brandy Faulkner; Courtney Thomas;

Gloria D. Smith Professor of Black Studies: Brandy Faulkner;

General Contact: jenkin04@vt.edu

Graduate Site: <https://liberalarts.vt.edu/academics/graduate-programs/masters-programs/master-of-arts-in-political-science.html>

The Master of Arts in Political Science was established in 1969. Currently, the program enrolls 20 to 25 full-time students on campus each year and approximately 20 to 25 off-campus students in the On-Line Master of Arts in Political Science Program (OLMA/PSCI). This relatively small scale provides excellent opportunities for close student-faculty interaction in both the residential and on-line degree programs. The Master of Arts Program covers all sub-fields of the discipline, and it prepares students for careers in academe, government, non-profit and for-profit organizations. It is especially well suited for students who want to acquire sophisticated theoretical and analytical skills before either pursuing a doctoral degree in political science or entering careers in public or private research organizations. The usual course of study is four semesters of full-time graduate work. The first three semesters are used primarily for required foundation courses and elective coursework while the fourth is used to write a master's thesis. In recent years, M.A. students in political science have enrolled in this program from a wide variety of American colleges and universities. Students have also entered the M.A. program from a number of other countries including Argentina, Austria, Bolivia, Brazil, Canada, China, Colombia, England, France, Germany, Greece, India, Iran, Ireland, Israel, Mexico, Norway, Portugal, Romania, Scotland, South Korea, Sweden, Switzerland, and Turkey. Recent graduates have entered doctoral studies in Ph.D. programs at Arizona, Arizona State, California-Berkeley, California-Irvine, California-San Diego, Colorado State, Connecticut, Delaware, Denver, Duke, Florida International University, Florida State, Georgia, Illinois (Urbana-Champaign), Indiana, Iowa, Johns Hopkins University, Kentucky, London School of Economics, Massachusetts-Amherst, Maryland, Minnesota, Michigan State, Nebraska, North Carolina, Northeastern, Penn State, Pittsburgh, Purdue, Ohio State, Oregon, Oxford, Strathclyde, University of South Carolina, SUNY-Albany, SUNY-Stony Brook, Syracuse, Texas A&M, Texas-Austin, Washington University-St. Louis, Utah, Wisconsin, Virginia Tech, and Virginia. Other graduates have taken professional positions in government agencies, political parties, interest groups, research institutes and non-profits.

SPECIAL FACILITIES

504 Major Williams

Craig L. Brians Research Lab

The Craig L. Brians Research Lab is open to graduate students 24 hours a day. It contains several computers linked to the Internet and campus networks. A variety of research and word processing software is available for these machines. Knowledge of these resources combined with emphasis on quantitative and qualitative methods are assets to students who anticipate working in a public or private agency or at an educational institution. Students also have access to a wide variety of data sets through the University's membership in the Intercollegiate Consortium for Political and Social Research (ICPSR).

DEGREES OFFERED

MA Degree

Offered In (Blacksburg, Virtual)

TOEFL

Paper: (600.0), Writing (4.5)

iBT: (100.0), Writing (24.0)

GRE--Recommended

The degree requirements for the MA are 21 hours of coursework and 9 hours of Thesis and Research. Three classes are required: PSCI 5115-Research Methods I, 5116-Research Methods II, and 5214-Contemporary Political Theory (total of 9 cr.) and 4 electives (12 cr.).

GRADUATE COURSES (PSCI)

PSCI 5104 (SPIA 5104) (STS 5104):

Policy Gateway: Policy and Decision Making in Scientific Domains

Key concepts in policy making, including policy analysis and decision making in complex social and technical settings. Policy process theories and evaluation tools. Concepts of governance including public values, ethics, and variable impacts across communities. Relationships among public policy decision processes and science, technology, and engineering, including disciplinary norms. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PSCI 5114:

Critical Research Design

Analysis of challenges related to power and ethics in the design of political research. Special emphasis on research question formulation, case selection, identification of sources, and qualitative research

methods. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PSCI 5115 (GIA 5115):

Research Methods

The purposes, problems, and strategies of political science research, emphasizing concept and hypothesis formulation, operationalization, research design, data collection techniques, data processing, and multivariate data analysis.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PSCI 5116 (GIA 5116):

Research Methods

The purposes, problems, and strategies of political science research, emphasizing concept and hypothesis formulation, operationalization, research design, data collection techniques, data processing, and multivariate data analysis.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): PSCI 5115, STAT 5654

Corequisite(s):

PSCI 5124 (SPIA 5124):

Decision Making, Reflective Practice, and Engagement in STEM-H Domains

In-depth case-based exploration of roles of science, technology, engineering, and mathematics in policy-making. Application of theories, concepts and practices for policy decision-making, including stakeholder engagement, human behavior, and organizational development. Critical examination of ethics, and fostering of reflective practice. Implications of big data and modeling in decision-making. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

PSCI 5134:

Tools and Approaches for Policy-Making in STEM-H Domains

Techniques for translating theory-driven, qualitative concepts into quantitative data-focused modeling to address policy problems.

Quantitative and computational tools including statistical inference and hypothesis testing, system dynamics, and economic analysis. Modeling paradigms and common challenges in modeling. Modern data analytic practices, including good collection, storage and visualization techniques. Problem definitions and application to real-world policy-related problems and implementation in modern software packages.

Understanding complexity. Critical evaluation of challenges and common pitfalls in quantitative modeling. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PSCI 5154:

Science, Technology, and Engineering in Policy Seminar

Seminar for Science, Technology, and Engineering in Policy (STEP) program students. Presentation of research on the intersections of science, technology, engineering, math, and health (STEM-H), public policy, and ethics. Professional development. Research resources and tools. Project management and funding opportunities. Publishing standards and processes across disciplines. STEM-H and policy practitioner engagement. Multidisciplinary communication. May be repeated up to six times, as seminar and presentation topics will change each semester. Pass/Fail only. Pre: Graduate standing.

Credit Hour(s): 1

Lecture Hour(s): 1

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PSCI 5164:

Collaborative Governance and Civil Society

Theoretical foundations of collaborative policy and governance approaches are examined. Strategies and methods for forming and sustaining collaborative coalitions are discussed. Case studies are used to illustrate the effectiveness of collaborative approaches in different policy domains.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PSCI 5214 (GIA 5214):

Contemporary Political Theory

Selected topics in contemporary political theory, including different models of social science inquiry and the use of basic concepts like power, ideology, rationality, and the state in the study of politics.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PSCI 5224:

Alternative Perspectives in Political Theory

Analysis of selected perspectives on politics including: rational choice theory, critical theory, neo-marxism, neo-conservatism, post-industrialism, and post-structuralism.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PSCI 5254 (GIA 5514):

Global Conflicts

Examines theoretical issues in the study of global conflicts. Reviews theories of nationalism, states and territory as factors. Examines dynamics of contemporary conflicts from different regions of globe as case studies illustrating theoretical issues. Reviews role of leaders in conflict processes. Graduate Standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PSCI 5284 (GIA 5284):

Overview of the dynamics, policies, governance, and citizenship regimes associated with the phenomenon of transnational migration. The course will emphasize local, national, and supranational examples and comparisons to explore these themes. Graduate standing

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PSCI 5314:

Legislative Branch

The legislative process in American state and federal governments including recruitment of members, organization and functioning of legislative systems, and relations with both constituents and other branches.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PSCI 5324:

Executive Branch

The executive office and bureaucracy of American state and federal governments including recruitment, organization of executive branches, decision making, leadership styles, and relations with other branches.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PSCI 5334:

Judicial Branch

The American judicial system including recruitment of personnel, uses of the courts, judicial policy, relations with other branches, judicial behavior, and the impact of court decisions.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PSCI 5344:

Political Behavior

Approaches to the study of political behavior including political psychology, rational choice, biopolitics, socialization, communication, public opinion, and political participation.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PSCI 5354 (GIA 5354):

Public Policy Analysis

Approaches to policy analysis and program evaluation including the techniques appropriate to various stages of the policy process.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PSCI 5364 (GIA 5364) (STS 5364):

Public Ecology

Examines policy developments and practices that move beyond the conceptual divisions and policy operations begun during the 1970s, which largely divided the more natural science-based environmental sciences from social science-based environmental based studies. Mixes the insights of life science, physical science, social science, applied humanities, and public policy into a cohesive conceptual and operational approach to environmental protection in the 21st century. Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PSCI 5374:

Electronic Governance

Examines applications of information technology in government from the point of view of governments and citizens. Survey of the relationship between e-government e-democracy and of government management techniques. Explores problematic issues related to e-government, such

as privacy, the digital divide, and information security.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): PSCI 5214, PSCI 5554 OR UAP 5564

Corequisite(s):

PSCI 5384:

Identity Migration and Place

Place-based identities and intersectional inequalities. Influence of these interrelated dimensions on the study of forced and voluntary migrations within and across national borders, and such discourses as home, belonging, nationhood, and citizenship.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): WGS 5114

Corequisite(s):

PSCI 5414 (GIA 5414):

Industrial Democracies

Political patterns and processes of development in selected democracies in Europe, North America, and Asia emphasizing the political problems of contemporary industrial societies and their likely evolution in a post-industrial era.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PSCI 5424 (SPIA 5124):

Communist and Post-communist Systems

Political processes and developmental trends in communist and post-communist systems in Russia and other CIS states, Eastern Europe, the Peoples Republic of China, and the Third World. Current economic, political, and social issues and their likely development.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PSCI 5434 (GIA 5434):

Politics of Developing Areas

Political structures, economic growth, and cultural frameworks of developing nations in Asia, Africa, and Latin America emphasizing the political and economic challenges of industrial development in a global economy.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PSCI 5444 (GIA 5444):

International Politics

Theories of international organizations and relations among nations focusing on research in foreign policy formulation and implementation, international integration, conflict resolution, and global political economy.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PSCI 5454:

Advanced Topics in Information Technology and Public Policy

In-depth study and critical evaluation of selected complex issues related to information technology, society, governance, and public policy. Focused attention is given to theoretical and methodological foundations of the area of inquiry and to specific domains of policymaking and implementation. Topics will be selected from IT-related issues in such areas of concern as: cities, local communities, nonprofit organizations, governments, and global networks. May be repeated on a different topic. Must meet prerequisite or have permission of the instructor.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): UAP 5564

Corequisite(s):

PSCI 5464:

Critical Security Studies

Provides an overview of the critical study of security in world politics. Introduces alternative conceptualizations of security to the military-

post-structuralist and critical theoretic attempts to conceptualize the nature of security. Compares and contrasts these approaches with widely-accepted understandings of security in light of key debates in contemporary security studies.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): PSCI 5444 OR GIA 5444

Corequisite(s):

PSCI 5474 (GIA 5474):

Global Governance

Examination of the norms, institutions and practices developed by the international community to address systemic global governance problems: genocide, failed states, transnational corruption, displaced persons, AIDS, poverty. Role of United States in World community examined. Power of international organizations versus states. Capacity problems of both. Future of United Nations and global governance considered. Graduate Standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PSCI 5484 (HIST 5484) (GIA 5484):

Contemporary American Foreign Policy

Covers U.S. foreign policy during the Cold War, the stalemate with the Soviet Union, armament and arms control, containment and deterrence, detente and Reaganism, and the end of the Cold War. Briefly covers events from 1989 to the present. Designed for students with an interest in foreign policy and global affairs. Prereqs or instructors permission.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): PSCI 5214, PSCI 5444

Corequisite(s):

PSCI 5504 (GIA 5504) (UAP 5504):

Discourse Analysis

Examines the key theoretical sources and major practical applications of discourse analysis as a contemporary social science methodology.

Origins, major variants, and critical uses of discourse analysis in cultural studies, semiotic methods, policy analysis, and organizational

communication techniques also are considered. Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PSCI 5514 (GIA 5514):

Global Security

Security examined as an essentially contested concept. Traditional national security and emergent global security discourses and agendas explained. Security institutions and organizations analyzed. Questions of power, identity and representation examined as factors delimiting security conceptions, practices and agendas. Graduate Standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

PSCI 5524:

U.S. Foreign Policy After September 11

Course offers a historical and analytical evaluation of U.S. foreign policy after this epochal change especially with regard to the war on terror, geopolitics in the Middle East, and relations with new global powers after the end of the Cold War.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): PSCI 5484

Corequisite(s):

PSCI 5554:

Culture, Politics and Society in Network Environments

Historical origins, institutional foundations, and theoretical interpretations of cultural, political, and social interaction through computer mediated communication are examined. Particular attention is given to new types of discourse, sources of power, and structures of society at all geographical levels in global computer and communications networks.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PSCI 5564:

Women and Globalization

Feminist theoretical paradigms that analyze impacts of globalization on women and girls. Impacts of globalization on households and families. Relationship between globalizing processes and gender inequalities. Addresses feminist controversies and women's transnational resistance.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PSCI 5584 (GIA 5584) (UAP 5584):

Environmental Politics and Policy

Course provides a broad introduction to the key ideas, actors and institutions related to environmental politics and policy in the United States, with some coverage of global issues. It is intended to provide students with basic interdisciplinary knowledge and an intellectual framework for understanding and thinking critically about environmental politics and policy.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PSCI 5614 (GIA 5614) (HIST 5544):

Understanding The Israeli Palestinian Conflict

Dynamics of the Israeli-Palestinian conflict. Critical issues that underlie the conflict and divide Israel and the Palestinians. Diplomatic efforts aimed at resolving the conflict. Pre: Graduate Standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PSCI 5644:

Womens Rights as Human Rights

International mechanisms for development and protection of women's human rights and their legal, political and cultural dimensions. Methods of strengthening and improving these mechanisms to prevent and

respond to women's human rights violations. Pre: Graduate Standing

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PSCI 5894:

Final Examination

NONE

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PSCI 5974:

Independent Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Independent Study, VI

Instruction Type(s): Independent Study, VI

Prerequisite(s):

Corequisite(s):

PSCI 5984:

Special Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PSCI 5994:

Research and Thesis

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research, Online Research

Instruction Type(s): Research, Online Research

Prerequisite(s):

237 Corequisite(s):

PSCI 6004:**Security, Governance, and Environmental Politics**

Application of approaches in political science to critical studies of governance, security, and the environment at subnational, national, and international levels. Advantages and disadvantages of critical approaches to environmental problems. Design of applied research projects in political science and for national and international policymakers.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): PSCI 5116, PSCI 5214, (PSCI 5474 OR GIA 5474), GRAD 5104

Corequisite(s):

PSCI 6114 (GIA 6114):**Critical Geopolitics**

Critical analysis of geopolitics as spatial discourse about world politics. Examines major concepts in critical geopolitics. Critically reads colonial, fascist, Cold War and post-Cold War geopolitical discourses. Discusses geopolitical knowledge in popular culture. Reviews latest research in the field of critical geopolitics. Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): PSCI 5444 OR PSCI 5444 (UG)

Corequisite(s):

PSCI 6124:**Topics in Security Studies**

Surveys the interface of globalization and security and the changing paradigm of security within global society. Reviews the impact of globalization on traditional understandings of state security and provides an advanced understanding of the emerging challenges and threats to human and state security. May be repeated with a different topic content for a maximum of 12 credits.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

PSCI 6144:**Topics in Global Governance**

Provides a comprehensive guide to the understanding of contemporary power pressures and responses to global economic and financial change along with its political and social repercussions. Reviews the fields of international political economy, demonstrates the various approaches to adherence and resistance to globalization, and explores the dynamics of the relationship between states and markets.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): GIA 5034 (UG) OR GIA 5034 OR UAP 5034 (UG) OR UAP 5034 OR PSCI 5034 (UG) OR PSCI 5034

Corequisite(s):

PSCI 6204:**Theories of Globalization**

Examination of past and present eras of globalization through various theoretical perspectives. Addresses colonialism and emergence of western models for development of poor countries. Controversies about impacts of current globalization on the nation-state, cultures, ecosystems, and racial/ethnic/gender inequalities. Explores present trends, such as globalization of agriculture and food systems, industrial production, migration, human rights, and anti-globalization resistance.

Prerequisite may be substituted for any equivalent 5000 level international course.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): UAP 5264 OR GIA 5264

Corequisite(s):

PSCI 6214 (GIA 6214):**Democracy Beyond the Ballot**

Forms of ultra or enhanced democracy outside of state institutions, particularly those developing in third sector organizations, theories of democracy and research on functioning deliberative democracies at the grassroots level, in societal or international institutions. Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): GIA 5034 OR UAP 5034 OR PAPA 5034 OR GIA 5164 OR UAP 5164

Corequisite(s):

PSCI 6224:**Competing Conceptions of the Third Sector**

Competing theories and conceptions of the third sector in relation to the for-profit firm and the state with international perspectives on voluntary grassroots action challenges and societal transformation. Integration of theoretical and research literatures in the field. Graduate Standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): GIA 5034 OR UAP 5034 OR PAPA 5034 OR GIA 5164 OR UAP 5164

Corequisite(s):

PSCI 6254:**National Security**

Application of security analysis tools to national security issues. Domestic and international security contexts, actors, and processes. Contemporary challenges to national security such as cyber-threats, terrorism, proliferation of weapons of mass destruction, pandemics and environmental threats, organized crime, drug and human trafficking, state failure and state- building, and migration.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): GRAD 5104, PSCI 5116, PSCI 5214, (PSCI 5464 OR ASPT 5464)

Corequisite(s):

PSCI 6444:**Topics in Environmental Politics**

Contemporary environmental politics. Impact of global climate, economic, and social change on the environment. Political and social repercussions of environmental challenges. Analysis of the dynamic relationships between states and markets in the context of environmental change. May be repeated with different content up to 9 credit hours.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): (PSCI 5364 OR STS 5364) OR (PSCI 5584 OR UAP 5584 OR STS 5584 OR GIA 5584)

Corequisite(s):

PSCI 6544:**Science, Technology, and Labor**

Examines issues of work, skill, and power in science and technology. Considers labor issues from a variety of perspectives, including social constructions of expertise; effects of technical change on the organization of work; industrial automation and deskilling; race and gender in divisions of labor; labor-saving technology in everyday life; invisible labor in information systems; and work practices in the production of science. Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PSCI 6984:**Special Study**

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PSCI 7994:**Research and Dissertation**

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research

Instruction Type(s): Research

Prerequisite(s):

Corequisite(s):

RHETORIC AND WRITING

Joseph Eska, Interim Chair

Professors: Katrina Powell;

Associate Professors: Sheila Carter-Tod; James Dubinsky; Derek Mueller; Kelly Pender;

Assistant Professors: Carolyn Commer; Chris Lindgren; Jennifer Sano-Franchini;

Graduate Contact: sashupe@vt.edu

Graduate Site: <https://liberalarts.vt.edu/academics/graduate-programs/phd-in-rhetoric-and-writing.html>

The PhD Program in Rhetoric and Writing at Virginia Tech focuses on rhetoric in society. We study language use and rhetorical activity in public, academic, corporate, and governmental settings in a collective effort to engage pressing social and cultural issues through academic discourse, public policy, and community outreach. As faculty and students at a land-grant university recognizing the history of our university's location upon indigenous lands, we engage in rhetoric and writing research that contributes to social progress, examines how literate practices create, circulate, and prioritize societal values and the public policies based on those values, and examines how rhetoric and writing empower and control access to power in these social systems. Our collective research agendas address rhetorical and social problems in such areas as: science and technology digital texts and publishing diversity and difference the environment scholarly inquiry medicine and disability education civic engagement globalized communication and commerce displacement and resettlement

SPECIAL FACILITIES

Center for Rhetoric in Society At the Center for Rhetoric in Society, we examine multiple rhetorics, bridging academic and public discourses to enact engagement and social change. Our mission is to investigate language use through rhetorical and narrative analysis to understand significant social problems. Graduate research assistants participate in all aspects of the Center, including grant writing, assisting faculty in research, organizing research symposia, and writing scholarly articles. See www.rhetoric.english.vt.edu/ for additional information.

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DEGREES OFFERED

PhD Degree

Offered In (Blacksburg)

TOEFL

Paper: (550.0)

Computer: (213.0)

iBT: (80.0)

Degree requirements will include 60 hours of graduate coursework past the bachelor's degree plus 30 hours of research and dissertation. Of those 60 hours of coursework, up to 30 may be transferred from an appropriate Master's degree. Because rhetoric and writing are inherently

interdisciplinary subjects, this program invites students to complete some coursework in related fields such as Language and Literature, Communication, Political Science, Human-Computer Interaction, Women's and Gender Studies, Science and Technology in Society, ASPECT, and Engineering Education, as well as courses in preparing the future professoriate offered by the Virginia Tech Graduate School. <http://www.liberalarts.vt.edu/academics/graduate-programs/doctoral-programs-list/phd-in-rhetoric-and-writing.html>

SCIENCE AND TECHNOLOGY STUDIES

Daniel Breslau, Head

Professors: Janet Abbate; Barbara Allen; Gary Downey;

Associate Professors: Daniel Breslau; James Collier; Saul Halfon; Philip Olson; Sonja Schmid; Matthew Wisnioski;

Assistant Professors: Ashley Hefflin; Rebecca Hester; Fabian Prieto-Nanez; Lee Vinsel;

Alumni Distinguished Professor: Gary Downey;

Collegiate Associate Professors: Matthew Goodrum;

General Contact: slusserc@vt.edu

Student Handbook: <http://www.sts.vt.edu>

Science and Technology Studies explores the relationship between science, technology, and society using a variety of disciplinary and interdisciplinary approaches. Research in STS analyzes how society affects the development and implementation of scientific, technological, and medical knowledges and practices and how scientific, technological, and medical pursuits affect society. The research and scholarly interests of STS faculty cross a wide range of disciplinary boundaries: some rely on fieldwork, others are immersed in historical or governmental archival research, while others develop social and conceptual analyses to answer theoretical or ethical questions. Graduate students in STS come from a wide range of backgrounds including the natural and physical sciences, engineering, numerous professional disciplines, liberal arts and humanities, history, anthropology, sociology, political science, and philosophy. Graduates emerge with an ability to identify and examine the conceptual, social, cultural, historical, and policy dimensions of science and technology. Courses leading to an M.S. or a Ph.D. in STS are available at two sites, Virginia Tech's main campus in Blacksburg and the National Capitol Region (NCR) in the greater D.C. metro area.

SPECIAL FACILITIES

Lane Hall. The STS administrative offices are located in 122 Lane Hall. Individual faculty offices are located in Lane Hall as well as other buildings on campus. The National Capital Region is located at 2054 Haycock Road, Falls Church, VA.

Lane Hall

The STS administrative offices are located in 122 Lane Hall. Individual faculty offices are located in Lane Hall as well as other buildings on campus. The National Capital Region is located at 2054 Haycock Road,

Falls Church, VA.

DEGREES OFFERED

MS Degree

Offered In (Blacksburg, National Capital Region)

TOEFL

Paper: (577.0)

iBT: (90.0)

Computer: (233.0)

MS course requirements can be found on this website:

<https://drive.google.com/file/d/0BwSZF3oYTnaBelpFV00tYk1XNE0/view>

PhD course requirements can be found on this website:

<https://drive.google.com/file/d/0BwSZF3oYTnaBNnhDWmNzN1N5Tjg/vi>
ewFor further information, contact Carol Sue Slusser at slusserc@vt.edu

PhD Degree

Offered In (Blacksburg, National Capital Region)

TOEFL

Paper: (577.0)

Computer: (233.0)

iBT: (90.0)

GRE

General Test: Verbal, Quantitative, Analytical

MS course requirements can be found on this website:

<https://drive.google.com/file/d/0BwSZF3oYTnaBelpFV00tYk1XNE0/view>

PhD course requirements can be found on this website:

<https://drive.google.com/file/d/0BwSZF3oYTnaBNnhDWmNzN1N5Tjg/vi>
ewFor further information, contact Carol Sue Slusser at slusserc@vt.edu

GRADUATE COURSES (STS)

STS 5014:

Science and the Public

Theoretical and practical aspects of the public's role in the development, application, and oversight of scientific and technological advances.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

STS 5024:

Introduction to Science and Technology Studies

Intellectual and institutional history of the field. Key theories, methods,

and domains of study. Relation among perspectives from contributing disciplines, and emerging interdisciplinary trends. Emphasis on both solid grounding through classic texts, and discussion of emergent research areas.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

STS 5104 (SPIA 5104) (PSCI 5104):

Policy Gateway: Policy and Decision Making in Scientific Domains

Key concepts in policy making, including policy analysis and decision making in complex social and technical settings. Policy process theories and evaluation tools. Concepts of governance including public values, ethics, and variable impacts across communities. Relationships among public policy decision processes and science, technology, and engineering, including disciplinary norms. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

STS 5105:

Contemporary Issues in Science and Technology Studies

Theoretical and methodological issues addressed in the interdisciplinary social study of contemporary science and technology. 5105: social studies of science; 5106: social studies of technology.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

STS 5106:

Contemporary Issues in Science and Technology Studies

Theoretical and methodological issues addressed in the interdisciplinary social study of contemporary science and technology. 5105: social studies of science; 5106: social studies of technology.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

STS 5124 (PSCI 5124) (SPIA 5124):

Decision Making, Reflective Practice, and Engagement in STEM-H

Domains

In-depth case-based exploration of roles of science, technology, engineering, and mathematics in policy-making. Application of theories, concepts and practices for policy decision-making, including stakeholder engagement, human behavior, and organizational development. Critical examination of ethics, and fostering of reflective practice. Implications of big data and modeling in decision-making. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

STS 5154:

Science, Technology, and Engineering in Policy Seminar

Seminar for Science, Technology, and Engineering in Policy (STEP) program students. Presentation of research on the intersections of science, technology, engineering, math, and health (STEM-H), public policy, and ethics. Professional development. Research resources and tools. Project management and funding opportunities. Publishing standards and processes across disciplines. STEM-H and policy practitioner engagement. Multidisciplinary communication. May be repeated up to six times, as seminar and presentation topics will change each semester. Pass/Fail only. Pre: Graduate standing.

Credit Hour(s): 1

Lecture Hour(s): 1

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

STS 5205 (HIST 5205):

Main Themes in the History of Science and Technology

Methods and concepts in the history of science and technology. 5205: research methods, interpretive approaches, and contemporary issues in the history of science; 5206: research methods, interpretive approaches, and contemporary issues in the history of technology.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

STS 5206 (HIST 5206):

Main Themes in the History of Science and Technology

Methods and concepts in the history of science and technology. 5205: research methods, interpretive approaches, and contemporary issues in the history of science; 5206: research methods, interpretive approaches, and contemporary issues in the history of technology.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

STS 5284 (NSEG 5284) (SPIA 5284):

Nuclear Nonproliferation, Safeguards, and Security

Technical essentials, policy analysis, theoretical perspectives of nuclear energy and nuclear nonproliferation. Fundamentals of the nuclear fuel cycle, management of international safeguards, threat of nuclear terrorism, and challenges for global nuclear industry. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

STS 5305:

Main Themes in the Philosophy of Modern Science and Technology

Problems, literature, and schools in the philosophy of science and technology. 5305: explanation and confirmation; 5306: theory change.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): PHIL 3505

Corequisite(s):

STS 5306 (PHIL 5306):

Main Themes in the Philosophy of Modern Science and Technology

Problems, literature, and schools in the philosophy of science and technology. 5305: explanation and confirmation; 5306: theory change.

Credit Hour(s): 3

242 Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

STS 5364 (PSCI 5364) (GIA 5364):

Public Ecology

Examines policy developments and practices that move beyond the conceptual divisions and policy operations begun during the 1970s, which largely divided the more natural science- based environmental sciences from social science-based environmental based studies. Mixes the insights of life science, physical science, social science, applied humanities, and public policy into a cohesive conceptual and operational approach to environmental protection in the 21st century. Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

STS 5424:

Topics in Science and Technology Studies

Variable topics in science and technology studies such as role of values in science and technology, risk assessment, and past and present relations of religion to science and technology. May be repeated to a maximum of 6 hours.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

STS 5444:

Issues in Bioethics

Identification and analysis of ethical issues arising in basic and applied biological, medical, environmental, ecological, and energy studies.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

STS 5514:

Research Designs and Practices for Sts

Examines research designs and practices that uncover historical relationships between knowledge contents and social dimensions of science, technology, and medicine. Includes archival research, archaeology of instruments and physical spaces, interviewing for knowledge content, logical and conceptual analysis, participant observation, questionnaires, and proposal preparation.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

STS 5614 (PAPA 5614):

Introduction to Science and Technology Policy

Strategies for science and technology policy; science education; scientific and technical information for societal uses; government and public policy; resource allocation; economy and global exchanges of science and technology; approaches to policy evaluation.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

STS 5974:

Independent Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Independent Study, VI

Instruction Type(s): Independent Study, VI

Prerequisite(s):

Corequisite(s):

STS 5984:

Special Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

STS 5994:**Research and Thesis**

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research

Instruction Type(s): Research

Prerequisite(s):

Corequisite(s):

STS 6234:**Advanced Topics in the History of Modern Science, Technology and Medicine**

Variable topics in history of science, technology, and medicine after 1800, such as the atomic age; space science; science, technology, and institutions; scientific and technological medicine; and environmental history. May be repeated with a different topic for a maximum of 6 credits.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

STS 6244:**History, Culture, and Politics of the Internet**

Explores a variety of social factors, past and present, that have affected the way we make, use, and think about computers and the Internet. Begins with the origins of the Internet and the people who shape this technology, from military strategists to hackers. Examines the ways diverse groups interact and build communities online and how cultural norms about race and gender shape the ways we participate in the world of computing. Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

STS 6314:**History of the Philosophy of Science**

Philosophers of science from 1650 to 1900 with particular attention to the historical development of views about the methods of induction and hypothesis and accounts of theory testing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

STS 6334:**Advanced Topics in Philosophy of Science**

Variable topics in advanced philosophy of science, including major theories of scientific explanation and their criticisms; philosophical foundations of statistics; naturalized philosophy of science. May be repeated for credit, with permission and different content, for a maximum of 12 hours.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

STS 6534:**Advanced Topics in Cultural Studies of STEM-H**

Variable topics in cultural studies of science, technology, engineering, mathematics, and health. May include theories of language and science, popular and public knowledges, cultural performances around science and technology, conceptions of health and the body, cultures of quantification, technology and identity, hierarchies and diversity in science and technology, and cross-cultural comparisons. May be repeated with different content up to a maximum of 12 credits.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

STS 6554:**Energy Policy Hist & Contemp**

Social-scientific perspectives in energy policy. National and international topics and controversies such as fossil fuel resources, climate change, energy security, and the debate over nuclear power. Comparison of international perspectives. Challenges involved with management and regulation of large technological systems, the politics of expertise at the intersection of global climate change and energy security, and the changing character of our global energy infrastructure. Pre: Graduate standing.

244 Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

STS 6564:

Risk in Contemporary Culture

Conceptual perspectives on social and cultural studies of risk.

Qualitative theories and tools for analyzing a wide range of risks in contemporary culture. Definitions of risk as opposed to concepts such as danger, hazard, and uncertainty. Perception of risk and selective bias in risk perception. Efficiency, objectivity, and morality as factors influencing risk assessment and risk management, and affective definitions of safety and reliability. Role of expertise, trust, and communication in risk regulation. Democratic policy instruments to facilitate stable, legitimate decisions about what risks to take or avoid in contemporary societies.

Pre: Graduate Standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

STS 6614:

Advanced Topics in Technology Studies

Variable topics in technology studies, including development and structure of knowledge in technology and engineering, social construction of technology, knowledge and power in technology, gender and technology, engineering in society, human/nonhuman relations in technology. May be repeated with a different topic for a maximum of 6 credits.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

STS 6664 (PAPA 6664):

Advanced Topics in Science and Technology Policy

Variable topics in science and technology policy. Includes advanced study of science, technology, and economy; science, technology, and power; strategies for research and development policy --public and private sector; transfer of technology; technological forecasting; government regulation and responses; science policy assumptions and

challenges, specialist knowledge and expertise; state and academic knowledge production; issues of race, class, gender, and national identity in policy work. May be repeated with a different topic for a maximum of 6 credits.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

STS 6674:

Advanced Topics in Alternate Perspectives On Science, Technology & Medicine

Variable topics in alternate perspectives. Includes science from scientists perspectives, indigenous knowledge forms, alternative medicine, New Age science, cyborg theorizing, heterodox perspectives. May be repeated with a different topic for a maximum of 6 credits.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

STS 6834:

Advanced Topics in Social Studies of Science, Technology, and Medicine

Variable topics in social studies of science, technology, and medicine, including studies of disciplines, institutions, boundaries, discourses, knowledges, and practices. May be repeated with a different topic for a maximum of 6 credits.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

STS 6984:

Special Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

STS 7994:

Research and Dissertation

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research

Instruction Type(s): Research

Prerequisite(s):

Corequisite(s):

SOCIOLOGY

James Hawdon, Interim Chair

Emeriti Faculty: Theodore Fuller; K Kiecolt; Donald Shoemaker; Barbara Smith; William Snizek;

Professors: Onwubiko Agozino; David Brunσμα; Toni Calasanti; Anthony Harrison; James Hawdon; Michael Hughes; Neal King; Anthony Peguero; Wornie Reed; Liesel Ritchie; John Ryan;

Associate Professors: Shannon Bell; Jennifer Bondy; Samuel Cook; Nicholas Copeland; Christine Labuski; Sarah Ovink; Paulo Polanah; Paula Seniors; Anastasia Vogt Yuan; Dale Wimberley; Bonnie Zare; Haiyan Zhu;

Assistant Professors: Andrea Baldwin; Letisha Brown; Thomas Dearden; Katalin Parti; Ashley Reichelmann; Theresa Rocha Beardall; Jason Roos; Donna Sedgwick;

Affiliated Faculty: Karen DePauw; Brandy Faulkner; Ellington Graves; Sharon Johnson; Karl Precoda;

Edward S. Diggs Professor in Humanities: Anthony Harrison;

Associate Professor of Practice: Suchitra Samanta;

Assistant Professor of Practice: Christina Hey;

Research Professors: Duane Gill;

Gloria D. Smith Professorship: Brandy Faulkner;

Graduate Contact: sbell33@vt.edu

Departmental Site: <http://www.sociology.vt.edu/>

The Department of Sociology at Virginia Tech is a premier, research-oriented program, with 34 full-time faculty members and 5 affiliated faculty. The common anchor that connects much of the research we do is a focus on the causes, consequences, and interactions of social inequalities in a variety of subfields, including gender, race, class, sexualities, criminology, health, aging, education, the environment, and the global political economy. A solid grounding in sociological theory and methods constitute the core of our graduate programs, and students may also specialize and/or take courses in our interdisciplinary programs in Africana Studies, Women's and Gender Studies, and American Indian Studies. In addition, we support the research of action-oriented scholars

who connect with communities in need and provide research that can help address social problems and influence public policy. Our faculty earned degrees from some of the finest doctoral programs in their fields. They have authored or edited over 60 books on such topics as workplace relations, Black Feminisms, Hip Hop, Indigenous communities in Southern Appalachia, Appalachian development, environmental justice, social movements, culture, gender, aging, sociology of knowledge, world systems, race in the marketplace, neoliberalism and authoritarian populism, rural violence, sexuality and bodies, deviance, drug use, higher education, research methods, and the mass media. Departmental faculty have published nearly 650 professional articles and chapters, written over 180 technical reports related to applied sociological issues, and participated in more than 80 externally funded projects. In addition, sociology faculty have received numerous college, university, and national awards for outstanding teaching, service, and research. Students earning a MS in Sociology gain the necessary background for doctoral work or careers in applied settings, such as business, federal or state government, and social services. Doctoral students establish their own programs of study, engage in their own independent research, teach their own undergraduate classes, present papers at professional meetings, publish in scholarly venues, and gain the credentials and skills necessary for careers in academia, government, or public policy.

SPECIAL FACILITIES

Virginia Tech's Department of Sociology is located in McBryde Hall. McBryde Hall houses exceptional teaching classrooms, and the department provides access to computer labs, faculty and graduate student offices, and administration resources.

DEGREES OFFERED

MS Degree

Offered In (Blacksburg)

TOEFL

Paper: (550.0)

Computer: (213.0)

iBT: (80.0)

GRE

General Test: Verbal (153.0), Quantitative (146.0), Analytical (4.0)

The Master of Science (M.S.) Degree has three options: Master of Science in Sociology, Master of Science in Sociology with a Concentration in Africana Studies, and a Master of Science in Sociology with a Concentration in Women's and Gender Studies. M.S. students must complete 24 hours of coursework, 6 hours of research, and write a thesis. All M.S. students must pass a final examination. The examination will be a defense of the thesis and an assessment of the student's understanding of appropriate sociological subjects. Specific course requirements, Requirements for the thesis, and procedures for the exam are discussed in the Graduate Catalog and the departmental Graduate Handbook.

Degree Concentrations:

Africana Studies

Please see Sociology Department Graduate Handbook for requirements of the Concentration in Africana Studies.

Women's & Gender Studies

Please see Sociology Department Graduate Handbook for requirements of the Concentration in Women's & Gender Studies. Students completing the requirements will receive a certificate in Women's & Gender Studies and a notation on the transcript.

PhD Degree

Offered In (Blacksburg)

TOEFL

Paper: (550.0)

Computer: (213.0)

iBT: (80.0)

GRE

General Test: Verbal (153.0), Quantitative (146.0), Analytical (4.0)

The PhD has three options: PhD in Sociology, PhD in Sociology with a Concentration in Africana Studies, and a PhD in Sociology with a Concentration in Women's and Gender Studies. PhD students must complete 48 hours of coursework and 30 hours of research. If a student has a MS or MA in Sociology or a related discipline up to 12 hours of coursework may be transferred and counted toward the 48-hour requirement. Students are required to complete classes in classical and contemporary sociological theory and an advanced theory course in one of our interdisciplinary programs. They are also required to complete a course in research methods, two graduate-level statistics classes, a qualitative methods course, an advanced methods course, and an academic writing class. PhD Students must also successfully pass a preliminary examination. The examination is to be taken after the student has completed approximately 45 hours of coursework. The preliminary exam is comprehensive in nature and tests a student's ability to integrate, synthesize, and apply sociological concepts in one area of concentration selected by the student. The exam may also test any aspect of theoretical sociology or research methodology. The student should meet with his or her exam area committee prior to preparing for the exam to discuss the exam and evaluation procedures. The departmental Graduate Handbook discusses these exams in detail. Ph.D. students must also complete a written dissertation and an oral dissertation defense (examination). Specific course requirements, requirements for the dissertation, and procedures for the examinations are discussed in the Graduate Catalog and the departmental Graduate Handbook.

Degree Concentrations:

Africana Studies

Please see Sociology Department Graduate Handbook for requirements of the Concentration in Africana Studies.

Women's and Gender Studies

Please see Sociology Department Graduate Handbook for requirements of the Concentration in Women's & Gender Studies. Students completing the requirements will receive a certificate in Women's & Gender Studies and a notation on the transcript.

GRADUATE COURSES (SOC)

SOC 5034:

Social Inequality

Perspectives on the sources and consequences of social inequality. Comparative analyses of the dynamic social construction of differentiation based on such markers as class, race, ethnicity, gender, age, religion, and sexual orientation, and the opportunities and constraints for life chances afforded by these processes.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

SOC 5104:

History of Sociological Thought

Examination of the social thinkers of the classical period in the development of sociological theory (e.g., Marx, Durkheim, Weber, Ward). Particular attention to the theories, methods, and goals developed by early sociologists.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

SOC 5114:

Contemporary Sociological Theory

Focus on sociological theorists since World War II, including Parsons, Merton, Dahrendorf, Coser, Homans, Blau, Blumer, Kuhn, and Garfinkel.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

SOC 5204:

Data Analysis

Examination of data analysis designs used in sociology with emphasis on the sociological interpretation of different kinds of analyses; practical applications as used in current research. 3 hours of statistics required.

Credit Hour(s): 3

Lecture Hour(s): 3

247 Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

SOC 5214 (PAPA 5214):

Research Methods

Research methods in sociology including survey methods, qualitative methods, and experimental design. The link between social theory and social research. Measurement, validity, reliability, and the logic of data analysis.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

SOC 5224:

Intermediate Data Analysis

Application of both common and more advanced quantitative data analytical techniques used in sociology and other social sciences, including multiple regression, regression diagnostics, logistic regression, and causal modeling. Emphasis on analysis and interpretation of sociological survey data using SPSS (Statistical Package for the Social Sciences) and presentation of multivariate analyses to a sociological audience.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): SOC 5204

Corequisite(s):

SOC 5234:

Sociological Issues in College Pedagogy

Examines economic, political, and public influences on higher education. Explores the implications of inequality in higher education for institutional change and effective pedagogy. Emphasis placed on the scholarship of teaching and learning, including assessment of pedagogical practices for learning-centered classes. Addresses curriculum development in sociology and techniques for overcoming student resistance in sociology classes. Pre-requisite: Graduate Standing required

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

SOC 5414:

Crime, Control, and Social Inequality

Dimensions of crime and systems of social control within a framework of social inequality; examines issues of social inequality, such as discrimination, relative to race and ethnicity, social class, and gender, in crime and systems of social control; international scope.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

SOC 5424:

Juvenile Delinquency Justice

Juvenile delinquency and the juvenile justice system, with particular attention to race, gender, social class, and age. Methods of collecting data and the extent and distribution of juvenile delinquency and juvenile gangs. Theories of delinquent behavior. Effectiveness of the juvenile justice system. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

SOC 5614 (AFST 5614):

Racial and Ethnic Health Disparities

Racial and ethnic health disparities in the United States. Contributions of social factors to inequality in medical care and health for minorities. Current and potential impacts of health care policies on health disparities. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

SOC 5624:

Women and Work

The analysis of the economic activities of women in contemporary society. The past and present relationship between women's domestic and market labor is examined, followed by an in-depth investigation of

womens labor force experiences. Competing sociological explanations are examined, providing the basis for exploring occupational segregation, inequalities of outcomes and comparable worth.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

SOC 5654:

The Global Division of Labor

Theory and research on the globalization of the division of labor during the recent past as well as over the past several centuries. Examines the development of the capitalist world-system including the role of technological forces; the roles of transnational corporations and states in the global economy; the effects of globalization on work and quality of life in the U.S., other developed countries, and the Third World; analyses of globalization in the manufacturing and service sectors; and possible solutions for problems associated with globalization.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

SOC 5714:

Aging in Social Context

Social, political, and economic environments of aging in a variety of cultures with emphasis on aging problems in American society. Evaluation of the major social theories of aging, their roles in defining problems of the elderly, and focusing on current social policy.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

SOC 5764G:

Advanced International Development Planning and Policy

Examination of major development theories and contemporary issues and characteristics of low-income societies (industrialization, urbanization, migration, rural poverty, hunger, foreign trade, and debt) that establish contexts for development planning and policy-making. Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

SOC 5894:

Final Examination

NONE

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

SOC 5914:

Orientation to the Discipline

Orientation for beginning graduate students to the organization of sociology, with emphasis on historical and departmental program areas and to the perspectives and specialties of departmental faculty; systematic and critical review of roles of sociologists, with particular reference to teaching, writing, professional association participation, and professional ethics.

Credit Hour(s): 2

Lecture Hour(s): 2

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

SOC 5974:

Independent Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Independent Study, VI

Instruction Type(s): Independent Study, VI

Prerequisite(s):

Corequisite(s):

SOC 5984:

Special Study

NONE

Credit Hour(s): 1 TO 19

249 Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

SOC 5994:

Research and Thesis

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research, Online Research

Instruction Type(s): Research, Online Research

Prerequisite(s):

Corequisite(s):

SOC 6204:

Survey Research Methods

Survey research techniques used in sociological research including applied sampling techniques, measurement, scale construction reliability, response effects, administration of survey instruments, data management, and data processing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): SOC 5204, SOC 5214, STAT 4524

Corequisite(s):

SOC 6214:

Sociological Issues in Qualitative Methodology

Examines the key components of qualitative methodology with a focus on sociological debates and issues that are contentious, unresolved, and problematic. Explores different methodological perspectives that are vying for prominence within sociology. Particular attention given to the role of gender, class, sexualities, age, race, nationality, ethnicity, disabilities, and colonialism in qualitative methodologies. Conduct qualitative research into the broader critique of the methodology including innovative methodologies being developed by qualitative sociologists.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): SOC 5214

Corequisite(s):

SOC 6414:

Theories of Crime and Delinquency

Examination of major theories of crime and delinquency, with application to specific examples, such as white-collar crime, gender-based patterns of crime and delinquency, and juvenile gangs. Also covers theories and issues concerning the control and prevention of crime and delinquency.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): SOC 5414

Corequisite(s):

SOC 6504:

The Sociology of Culture

Examination of sociological theory and research on culture, including theories of culture and society; culture as social practice; culture, class and identity; culture and collectivities; culture, power and institutions; the production of culture; cultural reception.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): SOC 5104 OR SOC 5114

Corequisite(s):

SOC 6524:

Sociology of Health

Examination of sociological theory and research on how social structures and social processes influence the health of individuals and populations. Emphasis on the health consequences of social inequalities by race, class, and gender; the effects of social contexts, networks, and institutions on health; and issues in health care.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): SOC 5204, SOC 5214

Corequisite(s):

SOC 6984:

Special Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Corequisite(s):

SOC 7994:

Research and Dissertation

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research, Online Research

Instruction Type(s): Research, Online Research

Prerequisite(s):

Corequisite(s):

THEATRE ARTS

Natasha Staley, Chair

Jacqueline Bixler, Program Director

Professors: Robert Leonard; Patricia Raun;

Associate Professors: John Ambrosone; Amanda Nelson;

Assistant Professors: Jane Stein; Tatiana Vintu;

Professor of Practice: Christopher Russo;

Instructors: Kathryn Murphy;

General Contact: theatreandcinema@vt.edu

Graduate Contact: rhleonar@vt.edu

Design/Tech Contact: jjastein@vt.edu

Graduate Site: <http://www.performingarts.vt.edu/study-with-us/theatre-graduate>

Department Site: <http://www.performingarts.vt.edu>

The Theatre and Cinema program, in the School of Performing Arts, is a highly successful and innovative program that is fully accredited by the National Association of Schools of Theatre and was the first program in the state to attain that status. The department offers a Master of Fine Arts degree in Theatre Arts, which is designed to train students for professional employment and leadership in the field, while providing a terminal degree in the profession. Areas of concentration include Theatre Design/Tech (scenographic, lighting, costume, properties, and technical direction), Directing & Public Dialogue, Arts Leadership, and Stage Management. The M.F.A. program focuses on an individualized plan of study for each student, characterized by one-on-one tutorials or small classes, realized production work, and close mentoring by faculty artists. This is surrounded by a vision of professional training that is most concerned with the formation of an individually specific attitude toward the artistic process, a way of thinking based on the ever-changing realities of today's arts world. It is a vision grounded in collaboration, relevance, and sustainability, favoring knowledge of current affairs and professional practices within an awareness of our sometimes common, sometimes separate, cultural heritages. Each M.F.A. candidate participates in the mounting of productions in the department, working side by side with faculty and staff. The annual production season generally includes four fully mounted main stage shows, workshop productions, and occasional summer shows. A strong relationship exists

with the Moss Arts Center and the Institute for Creativity, Arts, and Technology (ICAT), where students are provided further experiential opportunities. In addition, students have frequently worked on productions outside the department, both on and off campus, locally and beyond. A professional internship also is required for completion of the degree. The program remains small by design, accepting only a few students each year, to allow maximum production opportunities for the M.F.A. student. Every student accepted into the program is awarded an assistantship and full tuition waiver. Our graduates have been exceptionally successful in gaining employment upon completion of the degree. Interested persons are encouraged to visit our web site (<https://www.performingarts.vt.edu/>) to discover more about us.

SPECIAL FACILITIES

The mission and vision of the theatre production program is to produce new and contemporary plays and new visions of the classics to discover how our performances may connect and stimulate people in the many communities on and off the Virginia Tech campus. We find balance in the positive value of human connection - the interaction of mind, imagination, and spirit. As such, we believe that theatre is both a community event and a way to build community. Production and teaching facilities are located on the Blacksburg campus, primarily in Henderson Hall, Theatre 101 - a LEED-certified facility, and the Studio and Haymarket Theatres located in the Squires Student Center. Construction on Theatre 101 and the renovation of Henderson Hall were completed in the fall of 2009.

Classrooms and Labs

The renovated Henderson Hall houses general and dedicated classrooms, faculty offices, and fully equipped specialty labs, including: a CAD computer lab with multiple stations, a lighting design lab, a model-building lab, and an A/V sound and visual media design lab. Graduate student offices also are in this building.

Performance Venues

The Studio Theatre is a 214-seat three quarter thrust/modified proscenium designed by Theatre Arts faculty member Randy Ward. It features outstanding lighting, sound, and video systems, with a trap below and flexible actor access surrounding the stage area. A dismountable second level gallery is a readily available addition to the performance space. Its location directly in front of the Scene Shop makes set construction and loading remarkably convenient. The Haymarket Theatre in Squires Student Center is a 485-seat George Izenour designed traditional proscenium with continental seating and a 34-foot wide proscenium, lending to more traditional theatre works. It is fully equipped with sound, lighting, and fly systems. Theatre 101 is a state-of-the art teaching theatre space and classroom facility that opened in Fall 2009. It is a 42 x 42 square foot open space with a lighting grid at 18 feet above stage level. Audience risers and portable seating allow flexible staging configurations; a box office and dressing room add further support. This venue is used primarily for workshop productions directed by students and faculty and for occasional guest productions. The new facility has strong technical capability and a lobby front offering a public face to the campus and the town of

Blacksburg. Moss Arts Center is a brand new multi-faceted facility that incorporates a performance hall, gallery spaces, ICAT labs and performance spaces, classrooms, and offices. The new center brings professional artists and companies from around the globe to the Virginia Tech campus and community.

Production Support Facilities

The department maintains a fully equipped Scene Shop and Costume Shop for the construction of sets and costumes. The Scene Shop is a 3500 square foot space with 20 feet of clear height and an accessible loading dock, located immediately adjacent to The Studio Theatre. The Costume Shop is a 1200 square foot space featuring excellent resources for cutting, patterning, construction and finishing, fittings, and storage necessary for complete design and build of costumes and costume crafts. A Management Office provides support for promotion, publicity, front-of-house, and all management operations.

DEGREES OFFERED

MFA Degree

Offered In (Blacksburg)

TOEFL

Paper: (550.0)

Computer: (213.0)

iBT: (80.0)

Completion of the MFA degree in Theatre Arts requires: - A three-year program of study- A minimum 54 hours graduate credit- A required professional internship for one semester, usually in the third year, with a successful evaluation- A Final Project and Report, or sanctioned alternative (including a thesis option)The core of the curriculum lies in the studio format, one-on-one tutorials and small classes with the student's primary advisor. The educational value of the studio experience is based on regularly planned projects designed as experiential labs. The primary advisor mentors the artistic progress of the student through these projects and guides the development of each student's overarching goals and curricular needs. Each student participates in a required review with graduate committee members at the end of each semester of enrollment to evaluate work done, assess progress, and plan future projects and experiences. A unique Plan of Study, designed to the needs of each student, is developed to track progress toward the degree.

GRADUATE COURSES (TA)

TA 5015:

Graduate Seminar

Special topics in the theory and practice of theatre, current trends, and recent developments.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

TA 5016:

Graduate Seminar

Special topics in the theory and practice of theatre, current trends, and recent developments.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

TA 5315G:

Advanced Directing

Script analysis, theories, techniques, and practical applications of theatrical direction. Theories and aesthetics of directing, functions of the director, script analysis, basic principles and techniques of staging. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

TA 5316G:

Advanced Directing

Script analysis, theories, techniques, and practical applications of theatrical direction. Rehearsal techniques, style determination realism, and non-realism.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): TA 5315G

Corequisite(s):

TA 5415:

Production Studio I

Investigation of various fundamental production problems involving topic-oriented research, collaborative work, and individual projects. (2H, 2C minimum; 6H, 6C maximum) each.

Lecture Hour(s): 2 TO 6

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

TA 5416:

Production Studio I

Investigation of various fundamental production problems involving topic-oriented research, collaborative work, and individual projects. (2H, 2C minimum; 6H, 6C maximum) each.

Credit Hour(s): 2 TO 6

Lecture Hour(s): 2 TO 6

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

TA 5425:

Production Studio II

Investigation and experimentation with various advanced production problems involving topic-oriented research, collaborative work, and individual projects. (2H, 2C minimum; 6H, 6C maximum) each.

Credit Hour(s): 2 TO 6

Lecture Hour(s): 2 TO 6

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

TA 5426:

Production Studio II

Investigation and experimentation with various advanced production problems involving topic-oriented research, collaborative work, and individual projects. (2H, 2C minimum; 6H, 6C maximum) each.

Credit Hour(s): 2 TO 6

Lecture Hour(s): 2 TO 6

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

TA 5435:

Production Studio III

Investigation of specific production problems requiring the application of professional competencies (2H, 2C minimum; 6H, 6C maximum) each.

Credit Hour(s): 2 TO 6

Lecture Hour(s): 2 TO 6

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

TA 5436:

Production Studio III

Investigation of specific production problems requiring the application of professional competencies. (2H, 2C minimum; 6H, 6C maximum) each.

Credit Hour(s): 2 TO 6

Lecture Hour(s): 2 TO 6

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

TA 5504:

Topics in Theatrical Scenic Technology I

Topic-centered investigation in theatrical production process and management, or technical theatre design concepts. Examination of theories and practice through research, communication and collaborative practices. Theoretical examination and practical application of a range of approaches and trends in the field. May be repeated once for credit with different content, for a maximum of 6 credits. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

TA 5514:

Topics in Theatrical Scenic Technology II

Topic-centered investigation in structural design for the theatrical stage in either wood or steel. Mathematical examination of empirical techniques and methods through practical examples and the application of a range of common challenges in the field. May be repeated once for credit with different content, for a maximum of 6 credits. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

TA 5524:**Topics in Theatrical Scenic Technology III**

Topic-centered investigation in the physics, equipment, and automation involved in mechanical design for the theatrical stage. Examination of common practices through research, mathematical application, and practical application. Characteristic investigation and practical application of a range of approaches and trends in the field. May be repeated twice (2 times) for credit with different content, for a maximum of 9 credits. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

TA 5534:**Topics in Theatrical Scenic Technology IV**

Topic-centered investigation in drafting and geometry, and theatrical rigging. Examination of common drafting and rigging practices through examples, and practical application. Characteristic investigation and practical application of a range of approaches and trends in the field. May be repeated 1 time for credit with different content, for a maximum of 6 credits. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

TA 5614:**Topics in Art Leadership I**

Topic-centered investigation in arts management, leadership, or advocacy. Examination of theories and practice through research, communication and collaborative practices. Theoretical examination and practical application of a range of approaches and trends in the field. May be repeated two times for credit with different content, for a maximum of 9 credits. Pre: Graduate Standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

TA 5615:**Arts Management Studio I**

Topic-oriented investigation of various fundamental arts management problems involving research, collaborative work, and individual projects. (2H, 2C minimum; 6H, 6C maximum) each.

Credit Hour(s): 2 TO 6

Lecture Hour(s): 2 TO 6

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

TA 5616:**Arts Management Studio I**

Topic-oriented investigation of various fundamental arts management problems involving research, collaborative work, and individual projects. (2H, 2C minimum; 6H, 6C maximum) each.

Credit Hour(s): 2 TO 6

Lecture Hour(s): 2 TO 6

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

TA 5624:**Topics in Art Leadership II**

Topic-centered investigation in specialized areas of arts management: arts marketing, development (fundraising), or grant writing. Involves research, communication and collaborative practices, and individual projects. Theoretical examination and practical application of a range of approaches and trends in the field. May be repeated two times for credit with different content, for a maximum of 9 credits. Pre: Graduate Standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

TA 5625:**Arts Management Studio II**

Topic-oriented investigation and experimentation with various advanced arts management problems involving research, collaborative work, and individual projects. (2H, 2C minimum; 6H, 6C maximum) each.

Credit Hour(s): 2 TO 6

Lecture Hour(s): 2 TO 6

254 Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

TA 5626:

Arts Management Studio II

Topic-oriented investigation and experimentation with various advanced arts management problems involving research, collaborative work, and individual projects. (2H, 2C minimum; 6H, 6C maximum) each.

Credit Hour(s): 2 TO 6

Lecture Hour(s): 2 TO 6

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

TA 5634:

Topics in Art Leadership III

Topic-centered investigation in various areas of advanced arts management: human resources, financial management, or strategic management. Involves research, communication and collaborative practices, and individual projects. Theoretical examination and practical application of a range of approaches and trends in the field. May be repeated two times for credit with different content, for a maximum of 9 credits. Pre: Graduate Standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

TA 5635:

Arts Management Studio III

Topic/project-oriented investigation of specific arts management problems requiring the application of professional competencies. (2H, 2C minimum; 6H, 6C maximum) each.

Credit Hour(s): 2 TO 6

Lecture Hour(s): 2 TO 6

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

TA 5636:

Arts Management Studio III

Topic/project-oriented investigation of specific arts management

problems requiring the application of professional competencies. (2H, 2C minimum; 6H, 6C maximum) each.

Credit Hour(s): 2 TO 6

Lecture Hour(s): 2 TO 6

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

TA 5704:

Graduate Theatre Internship

Internship of one semester in production (technical theatre, design, or directing), child drama (theatre for youth or creative drama), or arts management (including stage management) with a professional theatre company or similar off-campus professional situation.

Credit Hour(s): 9

Lecture Hour(s):

Instruction Type(s): Lab

Instruction Type(s): Lab

Prerequisite(s):

Corequisite(s):

TA 5894:

Final Examination

NONE

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

TA 5904:

Project and Report

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research, Online Research

Instruction Type(s): Research, Online Research

Prerequisite(s):

Corequisite(s):

TA 5974:

Independent Study

NONE

Credit Hour(s): 1 TO 19

255 Lecture Hour(s): 1 TO 19

Instruction Type(s): Independent Study

Instruction Type(s): Independent Study

Prerequisite(s):

Corequisite(s):

TA 5984:

Special Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

TA 5994:

Research and Thesis

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research

Instruction Type(s): Research

Prerequisite(s):

Corequisite(s):

AEROSPACE ENGINEERING

Eric Paterson, Head

Professors: Alan Brown; Robert Canfield; William Devenport; Rakesh Kapania; Eric Paterson; Mark Psiaki; Pradeep Raj; Shane Ross; Christopher Roy; Joseph Schetz; Craig Woolsey;

Associate Professors: Jonathan Black; Stefano Brizzolara; Olivier Coutier-Delgosha; Scott England; Mazen Farhood; Kevin Lowe; Mayuresh Patil; Michael Philen; Jonathan Pitt; Gary Seidel; Cornel Sultan; Gregory Young;

Assistant Professors: Colin Adams; William Alexander; Seongim Choi; Christine Gilbert; Mathieu Joerger; Luca Massa; Bhuvana Srinivasan; Kevin Wang; Heng Xiao;

Research Faculty: Nanyaporn Intaratep;

NAVSEA Professor of Naval Ship Design: Alan Brown;

Norris and Laura Mitchell Professor of Aerospace Engineering: Rakesh Kapania;

Rolls-Royce Commonwealth Professor of Marine Propulsion: Eric Paterson;

Fred D. Durham Endowed Chair Professor: Joseph Schetz;

Kevin Crofton Professor: Mark Psiaki;

Research Associate Professors: Aurelien Borgoltz;

Research Assistant Professors: Matthew Kuester;

Professor of Practice: Harry Artis;

Graduate Contact: gradadvise-g@vt.edu

Student Handbook:

https://www.aoe.vt.edu/content/dam/aoe_vt_edu/programs/graduate/forms/AOE_Graduate_P-P.pdf

Graduate Site: <https://www.aoe.vt.edu/graduate.html>

Master of Science Degree The Department of Aerospace and Ocean Engineering offers a Master of Science Degree in Aerospace Engineering and in Ocean Engineering. Each of these degrees has two options, a Master of Science with or without thesis. Although both degrees require the same number of credit hours for graduation, the thesis option requires some of these credits be devoted to a research project. The non-thesis option can be obtained by taking only course work, or it can include credits for a project and report. Such a project and report is generally not research oriented, but deals with other aspects of an engineering problem and may involve a team of students. In order to ensure that all our students can communicate with scientists and engineers outside their primary field of interest, all students take at least one course in the general areas of aerodynamics, structures, flight mechanics and control, and numerical methods. In addition, students in the non-thesis program are required to take additional courses in their area of study. Students in this program have the opportunity to work on advanced research projects in the three areas mentioned previously as well as in the interdisciplinary arena where familiarity with two or more disciplines is required. As a result many of our students are in a position to satisfy the rapidly growing demand for well rounded engineers and scientists. Students following the thesis route work with faculty that have both national and international reputations in their respective areas of research. These areas pose exciting new challenges to the students who have the opportunity to work closely with their faculty advisor on current problems. These problems reflect the latest interests in new advancements in science and technology by NASA, Navy, Air Force, and various aerospace and non-aerospace industries. Our masters students do significant hands-on research and often work in teams with other masters and Ph.D. students on wide-range of topics, some focused in a newly developing area, and some multidisciplinary in nature. These activities include state-of-the-art research in aerodynamics, structures, flight dynamics and control, and multidisciplinary analysis and design. Students are encouraged to present their research results at conferences and in archival journals tied to industry and/or government or sponsored projects and include interaction with personnel and facilities from those organizations. The requirements for the degrees focused on applied physics or applied mathematics are slightly different from those of the other categories in that some required courses from the Aerospace and Ocean Engineering Department are replaced with others from either Physics or Mathematics respectively. These programs are specially tailored for students whose backgrounds are from outside the engineering environment and are interested in applying their skills to solving aerospace problems. Such programs encourage interaction with disciplines outside the usual engineering environment and result in new approaches to analyzing and solving problems. Master of Engineering Degree The Aerospace and Ocean Engineering Department offers a Master of Engineering degree in Aerospace Engineering. This degree requires the completion of a project and report which in some cases is required to be in conjunction with other students. For the Aerospace Engineering Degree, students are required to take at least one course in each general area of

aerodynamics, structures, and flight mechanics and control. This requirement is to insure that graduates from this program can operate in a multidisciplinary environment. In all cases the Master of Engineering program focuses on engineering type problems and their solutions. Doctor of Philosophy Degree The Aerospace and Ocean Engineering Department offers a Doctor of Philosophy Degree in Aerospace Engineering. This degree is a research oriented degree which can be focused toward one (or more) of several disciplines. These disciplines include Aero-Hydrodynamics, Dynamics and Control, Structures and Structural Dynamics, Ocean Engineering, Applied Physics, Space Engineering and Applied Math. All of these degrees require an in depth research project which will serve as the subject of the final dissertation. Research projects have been carried out in the areas of computational fluid dynamics (CFD), experimental fluid mechanics (both high and low speed), instrumentation development, composite materials, structural optimization, flutter analysis, nonlinear flight control, pilot- aircraft interactions, aerodynamic modeling, computer aided design, interdisciplinary design and optimization, trajectory analysis and optimization, space mechanics and space vehicle design, to name a few. Many of these programs are tied to industry and/or government sponsored projects and include interaction with personnel and facilities from those organizations. The requirements for the degrees focused on applied physics or applied mathematics are slightly different from those of the other categories in that some required courses from the Aerospace and Ocean Engineering Department are replaced with others from either Physics or Mathematics respectively. These programs are specially tailored for students whose backgrounds are from outside the engineering environment and are interested in applying their skills to solving aerospace problems. Such programs encourage interaction with disciplines outside the usual engineering environment and result in new approaches to analyzing and solving problems. Students in the PhD program work with faculty members known nationally and internationally for their contributions in their research area. Opportunities exist to work on the very latest research projects in the areas of aerodynamics, structures, flight dynamics and control, and multidisciplinary analysis and design. Many of these projects are in support of aerospace and non-aerospace industry, NASA, Navy and Air Force initiatives and include both analytical and experimental components. Modern computational and experimental facilities are available to each student including four subsonic wind tunnels and one supersonic wind tunnel. Advanced instrumentation is available for taking measurements of all type in these facilities.

SPECIAL FACILITIES

Research in Aerospace and Ocean Engineering poses exciting new challenges to the students who have the opportunity to work closely with their faculty advisor on current problems. These problems reflect the latest interests in new advancements in science and technology by NASA, Navy, Air Force, and various aerospace and non-aerospace industries. Our graduate students do significant hands-on research and often work in teams with other graduate students on wide-range of topics, some focused in a newly developing area, and some multidisciplinary in nature. These activities include state-of-the-art research in aerodynamics, structures, flight dynamics and control, and multidisciplinary analysis and design. Students are encouraged to present their research results at conferences and in archival journals tied to industry and/or government sponsored projects and include interaction with personnel and facilities from those organizations. Research in Aerospace and Ocean Engineering poses exciting new challenges to the students who have the opportunity to work closely with their faculty advisor on current problems. These problems reflect the latest interests in new advancements in science and technology by

NASA, Navy, Air Force, and various aerospace and non-aerospace industries. Our graduate students do significant hands-on research and often work in teams with other graduate students on wide-range of topics, some focused in a newly developing area, and some multidisciplinary in nature. These activities include state-of-the-art research in aerodynamics, structures, flight dynamics and control, and multidisciplinary analysis and design. Students are encouraged to present their research results at conferences and in archival journals tied to industry and/or government sponsored projects and include interaction with personnel and facilities from those organizations.

Aerospace Structures and Materials Laboratory (ASML)

The Aerospace Structures and Materials Laboratory (ASML) in the Aerospace and Ocean Engineering department at Virginia Tech is a research and educational facility dedicated to the understanding of structures and materials. The laboratory serves as an instructional center for students who are learning about structures related research at the undergraduate and graduate level. The facility is located in Room 15 of Randolph Hall.

Aerostructures Axial-Torsional Test Facility

This equipment is a large, multi-axial, servo-hydraulic testing machine purchased in 1988 from the MTS Systems Corporation (Eden Prairie, Minnesota), and it is located in 107 Hancock Hall. This machine is capable of simultaneously loading of test articles axially and torsionally, controlling either the axial load or axial displacement and controlling either torque or rotation. The computer automation (MTS TestStar workstation and Model 490 Digital controller) makes it possible to specify random independent biaxial loading on each axis in fatigue, or of a controlled phase relationship between each axis, or to input load spectrums obtained from field measurements, as well as providing data acquisition. The load unit has a fatigue load rating of 110,000 lbs axial and 50,000 lbs-in. torsional. The usable test space is 60 inches vertical spacing between actuator and load cell. Horizontal clearance between the load frame columns is 30 inches. The maximum stroke of the linear actuator is 6 inches, and the maximum rotation of the rotary actuator is 100 degrees.

Boundary Layer Research Wind Tunnel Laboratory

This research laboratory consists of a low-speed low-turbulence-intensity open-loop pressurized wind tunnel and associated equipment and instrumentation. Downstream of the blower a feedback-controlled rotating-blade damper can produce large-amplitude gusts up to 2 Hz, which is useful for simulating unsteady separating turbulent boundary layers in the test section. The test section is 3 feet wide and 24 feet long, has an adjustable upper wall that permits various streamwise pressure gradients, and has active suction and tangential wall-jet boundary controls on the non-test walls that are used to prevent unwanted stalls in strong adverse-pressure-gradient and unsteady flows. This facility has been used over the past 28 years in a number of experimental studies. Custom-designed and constructed laser-Doppler anemometers have

been used. The results have revealed new features of the turbulence structure of turbulent boundary layers and separated flows. Recently Olcmen and Simpson (1995) developed a fiber-optic "5-velocity-component" laser-Doppler velocimeter system for measuring 3 velocity components simultaneously at one point (30 μm diameter) and 2 other velocity components at 2 other points. Turbulent convective heat transfer in 3-D and separated flows have also been examined in this facility (Lewis and Simpson, 1996). Currently, this facility and instrumentation are being used to define the second-order turbulence structure of three-dimensional flows around hull/appendage and wing/body junctions.

Center for Space Science and Engineering Research

The Center for Space Science and Engineering (Space@VT) comprises a group of faculty, students and staff devoted to the investigation of the space environment. We presently include members from the Bradley Department of Electrical and Computer Engineering and the Department of Aerospace and Ocean Engineering. The Center resides in the College of Engineering. Our mission is to provide forefront research, instruction, and educational outreach in the fields of space science and engineering utilizing a holistic approach of theoretical modeling, advanced simulation techniques, space system and instrument design, and experimental data acquisition, analysis and interpretation.

Dynamic Plunge-Pitch-Roll Apparatus (DyPPiR)

The DyPPiR represents the next generation in wind tunnel testing methodologies: simulation of true unsteady aerodynamics. The DyPPiR is essentially a hydraulically powered, computer controlled, three degree-of-freedom robotic arm that is used to force sting mounted wind tunnel models through general, large excursion, high rate, high Reynolds number maneuvers. The DyPPiR is being used to study the maneuvering performance of submarines and fighter aircraft, and future work will involve even transient racecar aerodynamics. In addition to standard force and moment measurements, surface skin friction measurements (for three-dimensional separation location detection) and surface pressure measurements are made, and a Doppler Global Velocimeter (DGV) will permit 3-component velocity measurements to be made in a plane in the flow at specific instances during a maneuver.

Graduate Computational Laboratory

The computational requirements for Aerospace and Ocean Engineering are often very demanding. Students require access to graphical workstations, super-computers, networking applications, and document processing facilities. Graduate students in Aerospace and Ocean Engineering have access to a wide variety of computer facilities. In addition to those resources provided by Virginia Tech and the College of Engineering, the Department maintains personal computers, graphics workstations, and powerful servers. The Graduate Computer Laboratory includes workstations all of which are equipped with a wide variety of application software.

Hypersonic Wind Tunnel

The Virginia Tech blow-down type high-speed wind tunnel which operates at speeds ranging from Mach 2 to 7 is shown in Figures 1 and 2. The blow-down type wind tunnel offers run times on the order of a few seconds at high Mach numbers with relatively steady flow conditions. This facility was obtained through our close and long-term collaborations with the Institute of Theoretical and Applied Mechanics of the Russian Academy of Sciences in Novosibirsk, Russia. Air (or other working gas) is supplied from a compressor to charge the storage bottles visible within the frame at the bottom. A special fast-acting control valve initiates flow into the plenum chamber. The flow then passes through a contoured, converging-diverging nozzle and out through the diffuser. Due to the working principle of the tunnel and the fast-acting control valve, there is only a slow decrease in total pressure during the run. The variation of the total pressure during the run is in the range of approximately 10%. For Mach numbers above 4, an electric heater raises the total temperature up to 800 K to prevent liquefaction. The nozzle exit diameter is 100 mm. The test cabin arrangement permits the use of relatively large in-stream models, especially at the higher Mach numbers. This facility can be used for aerodynamic problem investigations which involve proper values of Mach and Reynolds number, to try out new measurement methods in high-speed flows, and for laboratory instruction of students. This laboratory type facility produces a gas flow with good metrology features, which are comparable to the corresponding features of steady flow in modern wind tunnels. -Working gases: air, nitrogen, argon, helium, and other safe gases. The total mass of storage air in 8*40 dm³ bottles with pressure of 150 bars is 56 kg. Each run uses about 2.7 kg/s of pressurized gas. It is possible that standard bottles or a high-pressure compressor with low delivery (capacity) will be used as a working gas supply. The upper limit of stagnation pressure in the storage bottles is $P_b = 15 \text{ MPa}$. The upper limit of stagnation temperature is $T_o = 800 \text{ K}$. The minimal values of stagnation pressure P_s and temperature T_s within the test chamber and diffuser are Table No. 1. test section size is 100mm. -Electric heater (220/380 V) with capacity 15 - 20 kW provides the flow stagnation temperature up to 800 K to prevent condensation of air at hypersonic speeds. -Tested models usually have the length 200 - 300 mm at the angle of attack 00 - 100 and 80 - 120 mm at the angle attack up to 400 - 500. The diameter of tested models is 20 - 40 mm. -Inner dimensions of test chamber are 360*226*200 mm. -Run duration depends on the test conditions and is usually from 1.0 to 2.0 s. During this time the flow stagnation pressure and temperature decrease smoothly nevertheless relative flow parameters and Mach number keep their constant values. - Axisymmetric replaceable contoured nozzles are fitted to the flange of a settling chamber.

Kentland Experimental Aerial Systems (KEAS) Laboratory

The Kentland Experimental Aerial Systems (KEAS) Laboratory is located at Virginia Tech's Kentland Farm agricultural research facility, which

includes about 1800 acres of university-owned farmland in a sparsely populated area southwest of the main campus. The 300 ft by 70 ft asphalt airstrip located at the center of the Kentland Farm is routinely used to support small unmanned aerial vehicle (UAV) flight operations. The airfield includes a state-of-the-art weather station to log meteorological data. A wireless network covering the area provides direct internet access. The adjacent UAV hangar provides nearly 2000 sq ft of workspace to support research, education, and outreach. The KEAS Lab was developed with support from the: College of Agriculture and Life Sciences Department of Plant Pathology, Physiology, and Weed Science College of Engineering Department of Aerospace and Ocean Engineering Department of Mechanical Engineering Institute for Critical Technology and Applied Science Office of the Vice President for Research Virginia Center for Autonomous Systems The KEAS Lab's primary purpose is to enable research collaborations involving UAVs among university faculty. However, the facility is available to others in the university community who have a research, educational, or outreach related need.

Low Speed Cascade Wind Tunnel

The Low Speed Compressor Cascade Wind Tunnel was designed to simulate conditions found near the tips of fan blades in high bypass ratio aircraft engines. Coincidentally it is also a fairly good representation of flow near the blade tips of a marine propulsion pump. It is sited in the basement of Randolph hall. The cascade consists 8 cantilevered GE rotor B section blades mounted with an adjustable tip gap. The blades are fabricated from aluminum and have a total chord of 10" and an effective span of 10". The blades are instrumented with mean surface pressure taps, and a microphone array for unsteady surface pressure measurement. The cascade configuration has a rectangular cross section of 65" by 10". The blade spacing is 9.29", and the stagger angle of the cascade is 56.93 degrees. The inlet angle of the cascade is 65.1 degrees. The centrifugal fan powering the facility produces a free stream velocity of about 25m/s resulting in a chord Reynolds number of close to 400,000. Instrumentation regularly used with the facility includes a two-axis computerized traverse, single and 3-component hot-wire anemometry, a 3-component fiber-optic LDV system, and instrumentation to sense the instantaneous position and speed of the belt. Work is being conducted on this facility by research groups under the direction of Dr. William Devenport and Dr. Roger Simpson. Recent sponsors include the Office of Naval Research and NASA Langley.

Nonlinear Systems Laboratory (NSL)

The Nonlinear Systems Laboratory (NSL) in the Aerospace and Ocean Engineering department at Virginia Tech provides a facility for research and instruction in dynamics and control of nonlinear systems. Founded by Dr. Craig Woolsey and Dr. Naira Hovakimyan in 2005, the NSL is now co-directed by Dr. Cornel Sultan, Dr. Mazen Farhood, and Dr. Woolsey. The NSL is a Core Laboratory in the Virginia Center for

Autonomous Systems (VaCAS).

Open Jet Wind Tunnel

The open jet wind tunnel was designed in the Fall of 2008 by members of the Aerospace & Ocean Engineering faculty and constructed in 2009 in the AOE machine shop. This research quality facility main purpose is to serve as an educational tool for undergraduate instruction. The open-jet wind tunnel is a blower type, open circuit facility shown in Figure 1. A steel frame at the base of the facility provides stability while the combination of aluminum composite panels and extruded aluminum frame results in a light weight yet strong structure. The tunnel is powered by a 30hp BC-SW Size 365 Twin City centrifugal fan capable of up to 15m³/s. The fan discharges into a 60, 4m-long diffuser. The flow is then directed into a 1.47m-high by 1.78m-wide settling chamber. A combination of 0.01m-cell size, 0.09m long honeycomb followed by three turbulence reduction screens (made of 0.3mm-diameter fiberglass screen with a 55% open area ratio) ensure a low turbulence and uniform flow. The flow then discharges in the atmosphere through a 5.5:1 contraction nozzle based on a 5th degree polynomial profile. Flow speed is controlled by an AF-600 General Electric variable frequency drive. At a maximum fan speed of 1180 RPM, the flow exits the 5.5:1 contraction at 30m/s. The flow velocity is measured using static pressure taps located at the exit of the settling chamber. A manometer mounted on the side of the tunnel measures the difference between the settling chamber static pressure and the atmospheric. To minimize the impact of the flow on the lab environment, the tunnel is equipped with a jet catcher located 1.2m downstream of the contraction exit (as seen in Figure 2). The main purpose of the jet catcher is to deflect and defuse the stream of air. The jet catcher is made of an extruded aluminum frame with composite panels. Two fiberglass high-loss screens inside the catcher deflect the flow towards the ground and ceiling. Further high-loss screens located at the top and bottom of the jet catcher reduce the flow velocity before it enters the room. For model mounting, the tunnel is also equipped with an adjustable support frame (shown in Figure 2). The frame is built out of extruded aluminum beams. The various slots on these beams provide great flexibility for positioning models.

Supersonic Wind Tunnel

The Virginia Tech 23 x 23 cm supersonic/transonic wind tunnel was designed and originally constructed at the NASA Langley Research Center. In 1958, the tunnel was purchased by Virginia Tech and put into operation in 1963. During recent years, several modifications were introduced into the air pumping, tunnel control, and instrumentation equipment which increased the capabilities of the facility. The air pumping system consists of an Ingersoll-Rand Type 4-HHE-4 4-stage reciprocating air compressor driven by a 500 hp, 480V Marathon Electric Co. motor. The compressor can pump the storage system up to 51 atm. A drying and filtering system is provided which includes both drying by cooling and drying by absorption. Air storage system consists of two

tanks with a total volume of 23 m. Tunnel control system includes quick opening butterfly valve and a hydraulically actuated pressure regulating 30.5 cm diameter valve. The settling chamber contains a perforated transition cone, several damping screens, and probes measuring stagnation pressure and temperature. The nozzle chamber is interchangeable with two-dimensional contoured nozzle blocks made of steel. The tunnel is equipped with three complete nozzle chambers which presently are fitted with the nozzles for the Mach numbers 2.4, 3.0, and 4.0. The working section of the tunnel is equipped with a remotely controlled model support which allows one to vary the position of a model in the vertical plane. An arrangement for side wall model mounting is also available. An extractable mechanism can be provided for supporting the model during the starting and stopping of the flow. Due to large doors containing the windows in the nozzle and working sections a very good access to the model is ensured. Instrumentation A 30 cm Schlieren apparatus uses two parabolic mirrors and air cooled high pressure mercury lamp. Shadowgraph pictures can be taken either with a direct-shadowgraph system or with a focused shadowgraph arrangement. A 1 microsecond spark source is used for this purpose. Interferograms may be taken with a laser-based single plate interferometer system and a CCD camera. To record flow phenomena of very rapid action and short time duration, the Hycam high speed motion picture camera can be used. The camera can be optically coupled with either Schlieren or shadowgraph apparatus. Operating speed limits are from 1,000 to 45,000 pictures per second. A six-component force and moment balance is also available. The main pressure measuring system includes a PSI Model 780B electronically scanned pressure system. The system is IBM PC computer controlled and presently can handle 32 pressure inputs (0 to 1 atm) simultaneously but, if a need arises, it can be expanded up to 512 pressure inputs. Pressure data rate is up to 20,000 measurements per second and the accuracy is 0.1% of span. In addition to the electronically scanned pressure system, there are two Scanivalve systems available, each allowing to record up to 48 pressures (0-3 atm) during a run of a few seconds duration.

Temperature and heat transfer measurements can be made using an automatic multipoint thermocouple reference system and high-speed potentiometric recorders. Data acquisition is all IBM PC based using modern software such as LabView.

Towing Basin

Modeling ship resistance is done by towing a model in a towing basin. The basin, located in the basement of Norris Hall is made of reinforced concrete painted with a chemical and moisture resistant enamel. The width of the basin is 6 feet and the maximum water depth is 4 feet. The overall length of the basin is 98 feet but the first 4 feet and the last 24 feet are used for braking the carriage. The usable test length is then approximately 70 feet. There are two glass walled observation pits along the side of the tank, one located approximately in the middle of the test

region and the other pit located at the starting end. The observation pit at the starting end is intended for use in the study of wave reflection and absorption. The carriage and rails were designed and constructed by the firm of Kempf and Remmers of Hamburg, Germany and were shipped in sub-assemblies to Virginia Tech. The allowable tolerance on rail height was 0.1mm. Wedges were used to give final straight alignment of each rail. The allowable tolerance on alignment was 0.2mm. Final alignment was done optically. After final adjustments in height were made, the space between the bearing plates and the bottom of the rail was filled with concrete. A 400 V DC motor drives the carriage through a gear reduction box. The DC power is supplied from a 220 V AC motor-generator set. A maximum speed of the carriage of 3.0 meters per second can be obtained. The carriage braking is done automatically using trips installed at both ends. An emergency brake button is also on the console. The brake is of the magnetic clutch type and brakes the DC motor directly. The brake is applied if power to the carriage is interrupted. Braking deceleration is 0.7 meter per second per second. Ocean Engineering undergraduate students perform two experiments in the basin. They test the resistance of both a surface ship and a submarine.

Transonic Cascade Wind Tunnel

The Virginia Tech Transonic Cascade Wind Tunnel is a blow down transonic facility capable of a twenty second run time. An overall layout is given in Figure X, and a photo is shown in Figure Y. The air supply is pressurized by a four-stage Ingersoll-Rand compressor and stored in large outdoor tanks. The maximum tank pressure used for transonic tests is about 1725 kPa (250 psig). A representative test section for gas turbine cascade testing is given in Fig. Y. Test sections for other types of testing such as a steam turbine cascade and compressor cascades have been used in this facility. During a run, the upstream total pressure is held constant by varying the opening of a butterfly valve controlled by a computerized feedback circuit. There is also a safety valve upstream of the control valve to start and stop the tunnel. The test section area is 37.3 cm high, and is designed for blades with an outlet angle of approximately 70 degrees. The blade isentropic exit Mach number is varied by changing the upstream total pressure; the usual range for exit Mach number is 0.7 to 1.35. The throat Reynolds number for typical tests is 340,000. Figure Z is a diagram of the test section. The tunnel mean flow is left to right on the figure, and is turned through 68 degrees by the blade passages, which act as the tunnel throat. Upstream of the blades, the bundle of three shock shapers protrudes from the test section top block; the shocks propagate down from the shaper exit to the bottom of the test section. The high-response total pressure probe for downstream surveys is also shown on the figure, pointing into the cascade exit flow. The probe moves up and down in line with wall static pressure taps. No tailboard is used downstream of the cascade, which means that a free shear layer forms between the exit plane of the blades

and the test section back wall. Note also the upstream total pressure probe, which is fixed at mid-pitch of the Lower passage. Instrumentation A 30 cm Schlieren apparatus uses two parabolic mirrors and air cooled high pressure mercury lamp. Shadowgraph pictures can be taken either with a direct-shadowgraph system or with a focused shadowgraph arrangement. A 1 microsecond spark source is used for this purpose. Interferograms may be taken with a laser-based single plate interferometer system and a CCD camera. To record flow phenomena of very rapid action and short time duration, the Hycam high speed motion picture camera can be used. The camera can be optically coupled with either Schlieren or shadowgraph apparatus. Operating speed limits are from 1,000 to 45,000 pictures per second. A six-component force and moment balance is also available. The main pressure measuring system includes a PSI Model 780B electronically scanned pressure system. The system is IBM PC computer controlled and presently can handle 32 pressure inputs (0 to 1 atm) simultaneously but, if a need arises, it can be expanded up to 512 pressure inputs. Pressure data rate is up to 20,000 measurements per second and the accuracy is 0.1% of span. In addition to the electronically scanned pressure system, there are two Scanivalve systems available, each allowing to record up to 48 pressures (0-3 atm) during a run of a few seconds duration. Temperature and heat transfer measurements can be made using an automatic multipoint thermocouple reference system and high-speed potentiometric recorders. Data acquisition is all IBM PC based using modern software such as LabView.

Virginia Tech Stability Wind Tunnel

The Stability Wind Tunnel is operated by the Aerospace and Ocean Engineering Department. With a 1.83m-by-1.83m test-section, it is one of the largest university operated wind tunnels in the United States with maximum speeds of 80m/s (corresponding to a Reynolds number of 5,000,000 per meter). In addition to its size, the flow quality is remarkable making it a prime research facility. The aerodynamic capabilities were recently increased by the addition of a removable anechoic test-section allowing for full-scale aero-acoustic testing. Since May, 2004, the facility has been under the direction of Dr. William Devenport, and currently employs one full time test engineer and several part time student employees. Detailed information about the Virginia Tech Stability Wind Tunnel can be found in the sections below. You can download the Stability Tunnel brochure for a summary of key features. The Virginia Tech Six Foot Stability Wind Tunnel was originally built at the NACA Langley Aeronautical Laboratory in 1940. It was designed to determine dynamic stability derivatives using a fixed model position, and was known at Langley as the "stability tunnel." Many of the NACA reports containing stability derivative data describe wind tunnel tests conducted in this tunnel. The wind tunnel was acquired by VPI in 1958, and the tunnel was erected in 1959 in a specially designed wing of Randolph Hall. Calibration of the tunnel was carried out from 1959 to

1961, when it became operational again. In 1994 the fan motor was completely overhauled and the windings reinsulated. In 1996 new fan blades were installed increasing the overall tunnel efficiency.

DEGREES OFFERED

MS Degree

Offered In (Blacksburg, Virtual)

TOEFL

iBT: (90.0)

GRE

General Test: Verbal, Quantitative, Analytical

Master of Science Requirements: Thesis and (Non-Thesis) 1. A minimum of 30 credit hours is required. For thesis students, up to 10 credit hours may be allotted for Research and Thesis (AOE 5994). For non-thesis students, up to 6 credit hours may be allotted for Project and Report (AOE 5904)[1]. 2. A minimum of 12 credit hours (15 for non-thesis) of graded course work numbered 5000 and higher must be included in the Plan of Study. These credit hours do not include the AOE Seminar (AOE 5944), Research and Thesis (AOE 5994) hours, or Project and Report (AOE 5904) hours. 3. A maximum of 6 credit hours (9 for non-thesis) of 5974 and 5984 is allowed. 4. A maximum of 6 credit hours of approved 4000 level course work is allowed. 5. Up to 50% of the courses on the Plan of Study may be transferred from a graduate program at another institution, subject to the approval of the Advisory Committee. Substitution of a transferred course for a specific required course is subject to the approval of the Graduate Program Director or a designee, usually the responsible instructor. Each transferred course must have a grade of B (3.0/4.0) or better. 6. All Aerospace Engineering M.S. candidates are required to take: AOE 4404, Applied Numerical Methods; AOE 5024, Vehicle Structures; AOE 5104, Advanced Aero and Hydrodynamics; and AOE 5204, Vehicle Dynamics and Control. The following additional required courses pertain to the three areas of specialization. Aero-Hydrodynamics: Thesis (non-thesis) students must take 9 (18) credit hours of approved electives. Electives for thesis students are determined in consultation with the Advisory Committee Chair. Non-thesis aero-hydrodynamics students must take two of the following three courses: AOE 5114, High Speed Aerodynamics; AOE 5135, Vehicle Propulsion; or AOE 5144, Boundary Layer Theory and Heat Transfer. Dynamics and Control: Thesis (non-thesis) students must take 9 (18) credit hours of approved electives. Electives for thesis students are determined in consultation with the Advisory Committee Chair. Non-thesis dynamics and control students must take one of the following two courses: AOE 5754, Applied Linear Systems; or AOE 5744, Linear Systems Theory; and students must take two of the following four courses: AOE 5234, Orbital Mechanics; AOE 5764, Applied Linear Control; AOE 5774, Nonlinear Systems Theory; or AOE 6744, Linear Control Theory. Structures and Structural Dynamics: Thesis (non-thesis) students must take 9 (18) hours of approved electives. Electives for thesis students are determined in consultation with the Advisory Committee Chair. Non-thesis structures and structural dynamics students must take the following two courses: AOE 5034, Mechanical and Structural Vibrations; and MATH 4574, Vector and Complex Analysis for Engineers. 7. All Ocean Engineering M.S. candidates are required to take: AOE 4404, Applied Numerical Methods; AOE 5074, Advanced Ship Structural Analysis[3]; AOE 5104, Advanced Aero and Hydrodynamics; and AOE 5334, Advanced Ship Dynamics. In addition, thesis (non-thesis) students must take 9 (18) hours of approved

electives, and non-thesis students must take 6 units of "Project and Report" or complete a 6 unit Capstone Naval Ship Design Project (AOE 5315 and AOE 5316). Electives for thesis students are determined in consultation with the Advisory Committee Chair. Non-thesis ocean engineering students must take two of the following courses: AOE 4024, An Introduction to the Finite Element Method; AOE 4264, Principles of Naval Engineering; AOE 5034, Mechanical and Structural Vibrations; AOE 5084, Submarine Design; AOE 5144, Boundary Layer Theory and Heat Transfer; AOE 5304, Advanced Naval Architecture; AOE 5305, Marine Engineering; AOE 5314, Naval Ship System Design and Effectiveness[4]; AOE 5374, Rationally-Based Design of Ocean Structures; AOE 5434G, Advanced Introduction to Computational Fluid Dynamics; AOE 5444G, Advanced Dynamics of High-Speed Craft; AOE 5454, Advanced Aerospace and Ocean Engineering Instrumentation; and AOE 6145, Computational Fluid Dynamics. 8. If a student has previously taken any of the required courses listed above or equivalent, while a Virginia Tech undergraduate or a student elsewhere, that course must be replaced with another course approved by the Advisory Committee. A student will not be allowed to repeat a Virginia Tech course (or an equivalent course from another institution) for a grade. A required AOE course can only be replaced with another AOE course. [1] Non-thesis Ocean Engineering M.S. candidates may take both AOE 5315-5316: Naval Ship Design to meet the 6 unit Capstone Naval Ship Design Project in place of 6 units of AOE 5904: Project and Report. [2] It is strongly recommended that students who wish to take AOE 6744, first take AOE 5744, Linear Systems Theory or an equivalent course on linear, time-varying systems. [3] If AOE 4274: Computer-Based Design of Ocean Structures has already been taken, then one of the following two courses must be substituted: AOE 5024: Vehicle Structures or AOE 5374: Rationally-Based Design of Ocean Structures. [4] It is strongly recommended that students who wish to take AOE 5314: Naval Ship System Design and Effectiveness, first take AOE 4264: Principles of Naval Engineering.

MEng Degree

Offered In (Blacksburg, Virtual)

TOEFL

Paper: (550.0)

Computer: (213.0)

iBT: (90.0)

GRE

General Test: Verbal, Quantitative, Analytical

Master of Engineering Requirements 1. The M. Eng. degree is a non-thesis degree. However, each candidate is required to prepare a paper, the subject and outline of which must be approved by the student's Advisor and Advisory Committee. The purpose of this paper is to develop and demonstrate the student's ability to plan and carry out projects or problems relating to engineering practice. This project is carried out under the auspices of a special project (AOE 5904: Project and Report). 2. A minimum of 30 credit hours is required, of which 3-6 credit hours must be allotted for AOE 5904. 3. A minimum of 15 credit hours (including 5974 and 5984) of graded course work numbered 5000 and higher must be included in the Plan of Study. 4. A maximum of 6 credit hours of approved 4000 level course work is allowed. 5. A maximum of 9 credit hours of 5974 and 5984 is allowed. 6. Up to 50% of the courses on the Plan of Study may be transferred from a graduate program at another institution, subject to the approval of the Advisory Committee. Substitution of a transferred course for a specific required course is subject to the approval of the Graduate Program Director or a

designee, usually the responsible instructor. Each transferred course must have a grade of B (3.0/4.0) or better. 7. A minimum of one approved math course is required. 8. All M. Engr. candidates are required to take: AOE 4404, Applied Numerical Methods; AOE 5024, Vehicle Structures; AOE 5104, Advanced Aero and Hydrodynamics; AOE 5204, Vehicle Dynamics and Control; and One additional AOE course. If a student has previously taken, while an undergraduate or student elsewhere, any of the specific required AOE courses above or equivalent, that course must be replaced with another AOE course acceptable to the Advisory Committee. A student will not be allowed to repeat a course from Virginia Tech or one that is equivalent from another institution for a grade. 9. The project described in requirement (1) may be carried out in conjunction with other students in the same program (e.g., a design project with several students of varied interests). Master of Science or Master of Engineering Requirements (AOE, Systems Option). The AOE Department, in conjunction with other interested departments in the College of Engineering, e.g. Industrial and Systems Engineering, offers an interdisciplinary degree in Systems Engineering. The requirements for the degree are essentially the same as those outlined above with the exception of the interdisciplinary aspect of the curriculum, which will be prescribed by the student's Advisory committee consisting of faculty from the AOE Department and the other relevant departments.

PhD Degree

Offered In (Blacksburg)

TOEFL

iBT: (90.0)

GRE

General Test: Verbal, Quantitative, Analytical

Doctor of Philosophy Requirements (beyond B.S.) 1. A minimum of 90 credit hours beyond the B.S. degree are required. 2. A minimum of 30 hours of Research and Dissertation (AOE 7994) must be included on the Plan of Study. All Ph.D. students must register for dissertation credit in accordance with the amount of time devoted to dissertation research. For example, a full-time research load would be 12 credit hours of dissertation credit, and would require a minimum of 40 hours per week of work devoted to research. 3. A minimum of 30 credit hours of graded course work numbered 5000 or above must be included. Up to 6 credit hours of 4000-level course work is allowed if approved by the PhD Advisory Committee. 4. A maximum of 9 credit hours of Independent Study (5974) and Special Study (5984) may be included. 5. A minimum of two consecutive semesters of full-time enrollment must be spent in residence at the Blacksburg campus (or with prior approval at some designated offcampus graduate center). At least 12 credit hours of course work (not including AOE 7994) must be earned while in residence. 6. Up to 15 credits of course work on the Plan of Study may be transferred from another university and is subject to the approval of the PhD Advisory Committee. Each transferred course must, (i) have a grade of B (3.0/4.0) or better, (ii) have been earned while in good standing in graduate status, and (iii) have been graduate courses at the institution where the student took the courses. Courses that are double-counted for both an undergraduate and graduate degree for students in Virginia Tech's UG/G Program are subject to the grade requirements for transfer courses. 7. All Ph.D. candidates are required to have taken or be enrolled in all of the courses on the Plan of Study by the semester in which the student presents the PhD Pre-defense. 8. AOE Course Requirement: All PhD candidates are required to take at least six AOE Courses. All graduate courses with an AOE number are considered AOE

courses. Any graduate course taught by an AOE faculty will also be considered an AOE course for this requirement. All courses on the list of Breadth courses (see below) can count towards both the AOE Course Requirement and the Breadth Requirement. a. Students may use transfer courses to satisfy this requirement. Substitution of a transferred course for a specific AOE course from the graduate course catalogue is subject to the approval of the Graduate Program Director on the recommendation of the responsible instructor. The student may request that a transfer course not listed in the graduate course catalogue be used to satisfy an AOE course requirement if the course is typically taught in an Aerospace or Ocean Engineering program. The Graduate Program Director will approve it on the recommendation of the PhD Advisory Committee. 9. Breadth Requirement: All PhD candidates are required to take at least one course each in three out of the four disciplinary areas identified below. a. The student must have taken or be enrolled in at least two of the three disciplinary breadth courses by the semester in which the student takes the PhD Preliminary Examination. b. Students may use transfer courses to satisfy this requirement. Substitution of a transferred course for a specific course listed below is subject to the approval of the Graduate Program Director on the recommendation of the responsible instructor. The student may request that a transfer course not listed below be used to satisfy a breadth requirement if the course is transferred from an Aerospace or Ocean Engineering program and primarily covers the breadth area. The Graduate Program Director will approve it on the recommendation of the AOE Graduate Committee. Fluid Mechanics Sample course list: i. AOE 5104, Advanced Aero and Hydrodynamics; ii. AOE 5114, High Speed Aerodynamics; iii. AOE 5124, Aero and Hydroacoustics; iv. AOE 5135, Vehicle Propulsion; v. AOE 5144, Boundary Layer Theory; vi. AOE 5304, Advanced Naval Architecture. Dynamics and Control Sample course list: i. AOE 5204, Vehicle Dynamics and Control; ii. AOE 5744, Linear Systems Theory; iii. AOE 5754, Applied Linear Systems; iv. AOE 5774, Nonlinear Systems Theory; v. AOE 5234, Orbital Mechanics; vi. AOE 5334, Advanced Ship Dynamics; vii. AOE 5444G, Advanced Dynamics of High-Speed Craft. Structures and Materials Sample course list: i. AOE 5024, Vehicle Structures; ii. AOE 5034, Mechanical and Structural Dynamics; iii. AOE 5054, Stability of Structures; iv. AOE 5064, Structural Optimization; v. AOE 5074, Advanced Ship Structural Analysis; vi. AOE 5374, Rationally-Based Design of Ocean Structures. Applied Physics Sample course list: i. AOE 5174, Introduction to Plasma Science; ii. AOE 5xxx, Spacecraft Propulsion; iii. AOE 5654, Introduction to Space Science I: The Solar Wind and Magnetosphere; iv. AOE 5664, Upper Atmosphere and Ionosphere; v. ECE 5194, Remote Sensing: Principles and Techniques. 10. Math Requirement: All PhD candidates are required to take at least one course (of three credits or more) focused on graduate-level mathematics, statistics, or numerical methods. A sample list of courses satisfying this requirement is given below. The PhD Advisory Committee can approve other courses (including transfer courses) that have majority of their learning outcomes on advanced mathematics, statistics, or numerical methods. i. AOE 5xxx, Numerical Methods in AOE ii. AOE 5434G, Advanced Introduction to Computational Fluid Dynamics; iii. AOE 5734, Convex Optimization; iv. AOE 6145, Computational Fluid Dynamics; v. AOE 6174, Computational Plasma Dynamics; vi. AOE 6314, Advanced Dynamics; vii. AOE 6444, Verification and Validation in Scientific Computing; viii. ESM 5734, Introduction to the Finite Element Method; ix. ESM 5744, Energy and Variational Methods in Applied Mechanics; x. ESM 6714, Applied Tensor Analysis; xi. ESM 6734, Finite Element Analysis; xii. MATH 5225, Real Analysis xiii. MATH 5235, Complex Analysis; xiv. MATH 5424, Numerical Linear Algebra; xv. MATH 5425, Applied Partial Differential Equations; xvi. MATH 5465, Numerical Analysis; xvii. MATH 5474, Finite Difference Methods for Partial Differential Equations; xviii. MATH 5484, Finite Element Methods for Partial Differential Equations;

xix. STAT 5044, Regression and Analysis of Variance; xx. STAT 5104, Probability and Distribution Theory; xxi. STAT 5434, Applied Stochastic Processes; xxii. STAT 5444, Bayesian Statistics; xxiii. STAT 5525, Data Analytics; xxiv. STAT 5616, Statistics in Research; xxv. STAT 5664, Applied Statistical Time Series Analysis for Research Scientists.

GRADUATE COURSES (AOE)

AOE 5024:

Vehicle Structures

Exact and approximate methods for analysis and design of aerospace and marine structures. Stresses, strains, constitutive equations, boundary value problems, and two-dimensional elasticity; torsion; variational methods; virtual work and energy principles; structural mechanics theorems; traditional approximate methods; and laminated plates.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

AOE 5034 (ESM 5304):

Mechanical and Structural Vibrations

Free and forced vibrations of single-degree-of-freedom systems, multi-degree-of-freedom systems, continuous systems including strings, rods, bars, and beams. Natural frequencies and modes. Rigid Body modes. Proportional and nonproportional damping. Response to harmonic, periodic, and nonperiodic excitations. Solutions by modal analysis, direct integration and Fourier Series. Approximate methods including assumed modes and the Rayleigh-Ritz method. Advanced topics chosen by instructor.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

AOE 5054 (ESM 5454):

Elastic Stability

Stability of elastic structural components under conservative loads; precise definitions of stability; energy approaches; Rayleigh-Ritz and Galerkin methods; and applications to column, arches, plates, and shells.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): AOE 3124 (UG) OR CEE 3404 (UG)

Corequisite(s):

AOE 5064:

Structural Optimization

Structural optimization via calculus of variations. Application of techniques of mathematical programming to optimize trusses, beams, frames, columns, and other structures. Sensitivity calculation of structural response. Approximation techniques and dual and optimality criteria methods. A background in optimization is necessary.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

AOE 5074:

Advanced Ship Structural Analysis

Analysis of plate bending, buckling, and ultimate strength using computational tools and methods. Calculation of elastic buckling of stiffened panels. Eigenvalue methods for buckling and vibration. Incremental plastic collapse; other progressive collapse. Ultimate strength of large structural modules due to combined loads. Introductory level finite element analysis. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

AOE 5084:

Submarine Design

Application of engineering disciplines to the design of a steam turbine propelled nuclear submarine. The disciplines involved are fluid mechanics, solid state mechanics, structures, machine design, thermodynamics and heat transfer.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

AOE 5104:

Advanced Aero and Hydrodynamics

Vector analysis concepts; fluid stress and strain, kinematics of fluid flows including vorticity; dynamics of inviscid incompressible flow; and potential flow theory with applications to lifting and non-lifting bodies.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

AOE 5114:

High Speed Aerodynamics

Aerothermodynamic phenomena and shock waves. Linearized subsonic and supersonic flow past planar surfaces and bodies of revolution. Theory of transonic aerodynamics including study of mixed flow. Similarity laws. Mathematical representation of inviscid compressible flows in equilibrium. Potential function, stream function, rotationality and geometrical considerations. Method of characteristics applied to hyperbolic flow fields. Discussion of techniques for solution of elliptic flow fields.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): AOE 3114 (UG)

Corequisite(s):

AOE 5124:

Aero and Hydroacoustics

Aeroacoustics for students familiar with the foundations of fluid dynamics. Fundamental theories of aeroacoustics, including Lighthill's analogy, the Ffowes-Williams-Hawkings equation and Goldstein's equation. Mathematical methods needed to and apply these theories, including correlation and spectral methods for turbulent flows.

Applications include the prediction of leading and trailing edge noise are taught. Relevant experimental methods, including facilities, corrections, instrumentation, signal processing and phased microphone arrays.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): AOE 5104

Corequisite(s):

AOE 5135 (ME 5135):**Vehicle Propulsion**

Aerothermodynamics of gas turbines and rockets: cycle analysis of turbojets, turbofans, prop fans, and turbo props. Analysis of ramjets and scramjets. Performance of inlets, combustors, and nozzles. Elementary theory of turbomachinery. Liquid and solid propellant chemical rockets. Electrostatic, electromagnetic, and electrothermal propulsion. Integrated rocket-ramjet. Fuels and propulsion systems for future transportation system.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): AOE 3114 (UG), ME 3134 (UG)

Corequisite(s):

AOE 5144:**Boundary Layer Theory and Heat Transfer**

Conservation equations and constitutive relations, exact Navier Stokes solutions; boundary layer approximation and special solutions; approximate methods; compressibility and heat and mass transfer effects; and numerical methods and simple turbulence models.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): AOE 5104

Corequisite(s):

AOE 5154:**Data Analysis in Fluid Dynamics**

Data analysis techniques and their role in fluid dynamics research. Fundamental tools for statistical analysis of random processes. Ways to obtain physical meaning from fluid dynamics data. Techniques for single-point statistics and correlation-based, multi-point statistics of data fields. Hypothesis-driven study of complex flow phenomena. Analysis of unsteady and turbulent flow emphasized. Pre: Graduate Standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

AOE 5164:**Fluid-Structure Interaction**

Review of essential elements of elastic vibration and basic fluid

mechanics; hydroelasticity based on potential flow theory; acoustic-structure interaction; dynamic aeroelasticity of airfoils; analytical solution of selected 1- and 2-D model problems; overview of computational models and methods for nonlinear fluid-structure interaction problems (e.g., partitioned and monolithic procedures, arbitrary Lagrangian-Eulerian, immersed/embedded boundary, interface tracking). Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

AOE 5174 (ECE 5174):**Introduction to Plasma Science**

Underlying physical processes and basic computational techniques for laboratory, space, and technological plasma environments including single particle motion, fluid and kinetic theory of plasmas, plasma waves and instabilities, diffusion and resistivity, and nonlinear effects. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

AOE 5204:**Vehicle Dynamics and Control**

Relevant rigid body kinematics and dynamics fundamentals for vehicles such as aircraft, spacecraft, and ships. Provides foundation for advanced courses and research on dynamics and control of vehicles. Review of particle motion and application to aircraft performance and satellite orbital mechanics. Rigorous modeling of rotational and translational motion of rigid bodies. Linearization of equations of motion for stability analysis, modal analysis, control system synthesis, with introduction to classical control system concepts. Sensors and actuators commonly used on vehicles. Specific examples from aircraft, missiles, spacecraft, rockets, ships, and submersibles.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): AOE 3134 (UG), AOE 3234 (UG) OR AOE 4140 (UG)

Corequisite(s):

AOE 5234:**Orbital Mechanics**

Lagranges equations of motion, two-body problem, conic sections, Keplers laws, orbit determination. Multi-body problems and integrals of motion. Fundamentals of perturbation theory, variation of parameters, and Lagranges planetary equations. Regularization and alternative formulations of equations of motion.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

AOE 5244:**Optimization Techniques**

Ordinary minimum problems with constraints. The classical multiplier method, descent methods, and quasi-Newton methods. Optimal control and the maximum principle. Second-order necessary conditions. Singular control. Continuous gradient methods, conjugate gradients.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): AOE 3134 (UG), MATH 4564 (UG)

Corequisite(s):

AOE 5304:**Advanced Naval Architecture**

Engineering analysis methods for evaluating the hydrostatic, hydrodynamic, and structural characteristics of surface ships and submarines. Methods employed in ship design include analytical, statistical, and experimental approaches. Both hull and propulsor analysis techniques are covered.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

AOE 5314:**Naval and Marine Engineering Systems Design**

Concepts, theory, and methods for the engineering, design, integration, and assessment of ship mechanical, electrical, fluid and naval systems. Description and functional physics of system components, system architecture, and the modeling of system effectiveness for

multidisciplinary and multi-objective design optimization. System integration, interfaces, and analyses considering ship arrangements, signatures, system deactivation diagrams and vulnerability, reliability, maintenance, system power, shock and weapons effects and damage control.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): AOE 5324

Corequisite(s):

AOE 5315:**Naval Ship Design**

Capstone naval ship design concept exploration including the study and application of the system engineering process to the simultaneous development of naval ship requirements, selection of ship technologies, and definition of a baseline naval ship design. Hullform, machinery, ship synthesis and balance, metrics (including Overall Measure of Effectiveness, technology risk, and cost) and design optimization in the context of a naval ship design project.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): AOE 5304, AOE 5314, AOE 5334, AOE 5074

Corequisite(s):

AOE 5316:**Naval Ship Design**

Development of a naval ship baseline design including hullform, combat systems, topside arrangements, internal subdivision and tankage, power and propulsion, auxiliary machinery, general arrangements, machinery arrangements, human systems, structural design, assessments of intact and damage stability, shock and survivability, weights, space, seakeeping, cost, risk, and overall balance and feasibility.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): AOE 5315

Corequisite(s):

AOE 5324:**Principles of Naval Engineering with Applications**

Basic functional principles and theory for naval engineering systems and system engineering processes. Particular emphasis is given to: naval

missions; combat system performance including radar; underwater acoustics and sonar; ballistics; weapon propulsion and architecture; weapons effects; ship survivability including underwater explosion and shock waves; surface ship and submarine hydrostatics, balance and feasibility analysis; and total ship integration. Pre: Graduate Standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

AOE 5334:

Advanced Ship Dynamics

Derivation of the equations of motion of a ship; waves and wave forces on structures; description of wave statistics and spectral representation in a given sea state; ship response in regular waves; ship response in random waves.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): AOE 3234 (UG), MATH 4564 (UG)

Corequisite(s):

AOE 5434G:

Advanced Introduction to Computational Fluid Dynamics

Euler and Navier-Stokes equations governing the flow of gas and liquids. Mathematical character of partial differential equations. Discretization approaches with a focus on the finite difference method. Explicit and implicit solution techniques and their numerical stability. Introduction to verification, validation, and uncertainty quantification for computational fluid dynamics predictions. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

AOE 5444G:

Advance Dynamics of High Speed Marine Craft

Study of the dynamics of high-speed craft, including surface effects ships, hydrofoil vessels, semi-displacement monohulls and catamarans, and planning vessels. Pre-requisite: Graduate Standing required

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

AOE 5464:

Combustion Chem & Diag

Combustion chemistry and laser-based combustion diagnostics from a fundamental, microscopic level. Statistical thermodynamics, molecular collisional models, chemical kinetics, reaction mechanisms for combustion systems, spectroscopy (absorption, Rayleigh, Raman, and Laser Induced Fluorescence), and diagnostics for measuring various combustion properties. Practical implementation and industrial applications. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

AOE 5604:

Modeling Composites Damage

Algorithms, techniques and tools applied in multiscale modeling of damage and failure in composite materials. Continuum level models, mesoscale models, and atomistic models. Analytic and computational techniques for capturing damage effects and conducting length scale transitions. Homogenization techniques, multiple scale expansion, finite element analysis, continuum damage models, cohesive zone models, dislocation dynamics, particle methods, and molecular statics and dynamics. Role of mesh-independent and meshless methods in modeling damage evolution. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

AOE 5614:

Modeling Multifunct Composites

Algorithms, techniques and tools applied in multiscale modeling of multifunctional composite materials. Continuum mechanics mathematical models for mechanical, thermal, and electromagnetic behaviors and linear and nonlinear couplings between them in active materials. Origins of coupled material response in active materials. Analytic and

composite properties based on active material constituents at the microscale.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

AOE 5654 (ECE 5164):

Intro to Space Science I

Describes the space environment from the sun to the earth's upper atmosphere. Fundamental concepts in space plasma physics will be presented, as needed, throughout the course. Numerous examples of observations and data will be utilized to illustrate the environment and its dynamic variability. An emphasis will be placed on the practical impacts of this environment and its dynamic variability. An emphasis will be placed on the practical impacts of this environment (space weather) on modern technologies such as solid state devices, satellite technology, communication and global navigation systems.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s): ECE 5105

AOE 5664:

Upper Atmosphere and Ionosphere

Fundamental concepts of solar-terrestrial physics; interaction of Earth's upper atmosphere and space environment with spacecraft; upper atmospheric composition, radiation, photochemistry and energy balance; structure of the upper atmosphere; impacts of transport and dynamics on the upper atmosphere; ionospheric composition, production and loss and its relation to Chapman theory; ionospheric structure; impacts of ionospheric electrodynamics; impacts of geomagnetic storms on the upper atmosphere and ionosphere; radio wave propagation; comparisons to other planets; details of atmospheric and ionosphere instrumentation. Pre: Graduate standing in Engineering.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

AOE 5734 (ECE 5734) (ME 5584):

Convex Optimization

Recognizing and solving convex optimization problems. Convex sets, functions, and optimization problems. Least-squares, linear, and quadratic optimization. Geometric and semidefinite programming. Vector optimization. Duality theory. Convex relaxations. Approximation, fitting, and statistical estimation. Geometric problems. Control and trajectory planning. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

AOE 5744 (ME 5544) (ECE 5744):

Linear Systems Theory

Advanced introduction to the theory of time-varying and time-invariant linear systems represented by state equations; solutions of linear systems, uniform stability and other stability criteria, uniform observability and controllability, state feedback and observers.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECE 4405 (UG) OR ECE 4405 OR ECE 4624 (UG) OR ECE 4634 OR ECE 4634 (UG) OR ECE 4634 OR ME 4504 (UG) OR ME 4504 OR AOE 4004 (UG) OR AOE 4004

Corequisite(s):

AOE 5754 (ECE 5754) (ME 5554):

Applied Linear Systems

Develop an applied understanding of state-space representations for linear time invariant multi-input multi-output dynamic systems in both time domain and frequency domain. Introduction to modern state-space control methods; state feedback and output feedback. Realistic design problems with numerical simulations of practical implementations.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECE 4405 (UG) OR ECE 4405 OR ECE 4624 (UG) OR ECE 4624 OR ECE 4634 (UG) OR ECE 4634 OR ME 4504 (UG) OR ME 4504 OR AOE 4004 (UG) OR AOE 4004

Corequisite(s):

AOE 5764 (ME 5564) (ECE 5764):

Analysis and design of sampled-data systems, extraction of discrete-time dynamic models from experimental data, and implementation of dynamic compensators on digital processors. In-depth design experience with LQR optimal control and an introduction to Kalman filtering. Realistic design problems with numerical simulations of practical implementations.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): AOE 5744 OR AOE 5754 OR ME 5554 OR ME 5544 OR ECE 5744 OR ECE 5754

Corequisite(s):

AOE 5774 (ECE 5774) (ME 5574):

Nonlinear Systems Theory

Introduction to the theory of systems of coupled, nonlinear, time-varying ordinary differential equations: existence and uniqueness of solutions; continuous dependence on parameters; stability of equilibria and stability analysis techniques; input-to-state stability; input-output stability; nonlinear design techniques including input-state and input-output feedback linearization, backstepping, and sliding mode control.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECE 4405 (UG) OR ECE 4405 OR ECE 4624 (UG) OR ECE 4624 OR ECE 4634 (UG) OR ECE 4634 OR ME 4504 (UG) OR ME 4504 OR AOE 4004 (UG) OR AOE 4004

Corequisite(s):

AOE 5784:

Model-Based Estimation and Kalman Filtering

Modeling of estimation problems including batch and dynamic problems; stochastic linear and nonlinear dynamic system models including Markov process models; batch nonlinear least-squares estimation; linear Kalman filtering and smoothing algorithms for dynamic problems; square-root information filtering and smoothing; nonlinear Kalman filtering, including the extended Kalman filter, the unscented Kalman filter, and particle filters; covariance analysis; filtering applications. Co: 5744 or 5754 or ECE 5744 or ME 5544 or ECE 5754 or ME 5554.

Credit Hour(s): 4

Lecture Hour(s): 4

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

AOE 5844 (CEE 5844):

Wave Mechanics

Linear wave theory including boundary value problems, wave transformation in shallow waters, long waves, and engineering properties of waves. Introduction to nonlinear wave theories. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

AOE 5894:

Final Examination

NONE

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

AOE 5904:

Project and Report

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research, Online Lecture, Online Research

Instruction Type(s): Research, Online Lecture, Online Research

Prerequisite(s):

Corequisite(s):

AOE 5914:

Autonomous Systems Seminar

Weekly technical presentations from local and visiting scholars on current topics related to the theory, design and development, and application of autonomous vehicle systems. Pre-Requisite: Graduate Standing required.

Credit Hour(s): 1

Lecture Hour(s): 1

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

AOE 5944:**Seminar**

Discussion of current research topics in Aerospace and Ocean Engineering by local and visiting scholars. This course cannot be used to fulfill the minimum requirements of 30 hours toward the Masters Degree or 90 hours toward the Ph.D. Degree in Aerospace and Ocean Engineering. May be repeated.

Credit Hour(s): 1

Lecture Hour(s): 1

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

AOE 5974:**Independent Study**

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Independent Study, VI

Instruction Type(s): Independent Study, VI

Prerequisite(s):

Corequisite(s):

AOE 5984:**Special Study**

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

AOE 5994:**Research and Thesis**

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research, Online Research

Instruction Type(s): Research, Online Research

Prerequisite(s):

Corequisite(s):

AOE 6024:**Aeroelasticity**

Discussion of the aeroelastic phenomena including flutter, divergence, control surface effectiveness, and lift redistribution; and introduction to traditional and modern methods of analysis and remedies for aeroelastic problems of flight vehicles.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): AOE 5034, AOE 5104, AOE 5214

Corequisite(s):

AOE 6064:**Reliability-Based Design Optimization**

Analyze uncertainties associated with mechanical and structural design.

Methods to model various uncertainties in a design using stochastic expansions and other probabilistic analysis tools. Computation of safety index and structural reliability using efficient techniques for implicit functions. Optimize designs under uncertainty.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): AOE 5064 OR AOE 5734 OR ECE 5734 OR ISE 5406 OR MATH 5485 OR ME 5584

Corequisite(s):

AOE 6114:**Transonic Aerodynamics**

Basic features of transonic flows, similarity methods, and hodograph methods. Major emphasis on finite difference procedures including type dependent relaxation procedures for potential flows and time asymptotic Euler solutions. Grid generation methods, inverse design procedures, unsteady flow, wind tunnel/wall interference, and shock wave/boundary layer interactions.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): AOE 3114 (UG), AOE 4404 (UG), AOE 5144

Corequisite(s):

AOE 6124:**Hypersonic Aerodynamics**

Theory of inviscid hypersonic flows; blunt body and Newtonian aerodynamics; nonlinear small disturbance theory; and approximate methods and comparisons with experiment. Viscous hypersonic flow

theory; skin friction and heat transfer on blunt and slender bodies; and vorticity, entropy layer, and viscous-inviscid inter-action effects.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): AOE 5114

Corequisite(s):

AOE 6145:

Computational Fluid Dynamics

Computational methods for incompressible, compressible, and viscous fluid flows. Theoretical and numerical developments for wave equation, heat equation, Poissons equation, and Burgers equation. Applications to inviscid subsonic, transonic, and supersonic flows, viscous boundary layer, Navier Stokes, thin layer equations, and grid generation techniques.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): AOE 3114 (UG), AOE 4404 (UG), AOE 5104

Corequisite(s):

AOE 6154:

Turbulent Shear Flow

Advanced treatment of the physical phenomena of turbulent boundary layers, jets, wakes, and duct flows; coherent structures; entrainment, bursting, vortex dynamics; and unsteady, wall, and freestream turbulence effects.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): AOE 5144 (UG)

Corequisite(s):

AOE 6174 (ECE 6174):

Computational Plasma Dynamics

Computational techniques for investigating processes in plasmas over a broad range of spatial and temporal scales. Investigation of physical processes including electrodynamics, waves and turbulence, space propulsion, spacecraft environmental effects and various laboratory applications. Computational techniques including full Particle-in-Cell (PIC), hybrid (fluid-electron, PIC ion), magnetohydrodynamics MHD and two-fluid methods.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECE 5174 OR AOE 5174

Corequisite(s):

AOE 6204:

Adv Vehicle Dynamics & Control

Topics in the dynamics and control of systems including airplanes, helicopters, spacecraft, and structures. Physics and data-based modeling from the control system designers perspective. Structure of the control-oriented equations of motion in relation to robust control design. Bio-inspired design.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): AOE 5204

Corequisite(s):

AOE 6234:

Advanced Orbital Mechanics

Canonical dynamics and applications to the two and three body problems. Classical and canonical variation of parameter equations of motion. Forces influencing Earth satellite motion are surveyed. Applications to Earth satellite motion. Additional topics from resonance, stability, periodic motion, numerical integration, and orbit determination.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): AOE 5234

Corequisite(s):

AOE 6254 (ESM 6254):

Turbulence Modeling and Simulation

In-depth study into the modeling and simulation of turbulent flows. Derivation of exact equations describing turbulent flows along with various approaches to turbulent closure. Turbulence modeling via algebraic, RANS, and Reynolds stress models. Turbulence simulation via DNS, LES and hybrid RANS/LES approaches and analysis of results. Turbulence compressibility effects, body forces, boundary conditions, wall functions, sub-grid modeling approaches, turbulence anisotropy and stress invariants, and realizability. Strengths and weaknesses of the different modeling and simulation approaches. Role of numerics in different modeling approaches. Pre: Graduating standing.

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

AOE 6314:

Advanced Dynamics

Fundamental concepts of analytical mechanics, variational principles, Lagranges equations, rigid-body kinematics and dynamics, Euler parameters, quasi-coordinates, Eulers equations, gyroscopic systems, Hamilton-Jacobi equation, transformation theory, introduction to optimal control theory, advanced concepts in stability theory.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ESM 5314

Corequisite(s):

AOE 6434 (ME 6434):

Computational Fluid Dynamics and Heat Transfer

Overview of numerical methods used in the study of computational fluid dynamics (CFD) and heat transfer. Spatio-temporal finite-difference, finite-volume discretizations, solution of linear systems with direct and iterative methods, algorithms for solving the Navier Stokes and energy equations, and turbulence modeling. Applications to inviscid subsonic, transonic, and supersonic flows and viscous boundary layer. Theory reinforced with hands on programming assignments and the application of commercial CFD packages to select problems.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ME 5404, ME 5314, ME 5104

Corequisite(s):

AOE 6444 (CS 6444) (ME 6444):

Verification and Validation in Scientific Computing

Applicable to scientific and engineering models described by partial differential or integral equations. Software engineering, code verification, and the method of manufactured solutions for generating exact solutions. Estimation of numerical approximation errors in scientific computing. Design and execution of experiments for model validation and model accuracy assessment. Propagation of aleatory and epistemic uncertainty through models. Estimation of total prediction uncertainty in scientific computing simulations. Graduate Standing required

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

AOE 6744 (ECE 6744) (ME 6544):

Linear Control Theory

Advanced introduction to the theory of optimal control of time-varying and time-invariant linear systems; Solutions to the linear-quadratic regulator, optimal filtering, and linear-quadratic-gaussian problems; Robustness analysis and techniques to enhance robustness of controllers.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECE 5744 OR ECE 5754 OR ME 5544 OR ME 5554 OR AOE 5744 OR AOE 5754

Corequisite(s):

AOE 6774 (ISE 6574) (ECE 6774) (ME 6574):

Adaptive Control Systems

Introduction to the theory and methodology used to design adaptive controllers for uncertain systems, addressing issue such as input constraints, disturbance rejection, partial measurements, and robustness.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): (ECE 5774, ECE 5744) OR (ME 5544, ME 5574) OR (AOE 5774, AOE 5744)

Corequisite(s):

AOE 6974:

Independent Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Independent Study, VI

Instruction Type(s): Independent Study, VI

Prerequisite(s):

Corequisite(s):

Special Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

AOE 7994:

Research and Dissertation

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research, Online Research

Instruction Type(s): Research, Online Research

Prerequisite(s):

Corequisite(s):

BIOLOGICAL SYSTEMS ENGINEERING

Dwayne Edwards, Head

Emeriti Faculty: John Cundiff; Conrad Heatwole;

Professors: Justin Barone; Brian Benham; Dwayne Edwards; Robert Grisso;

William Hession; Saied Mostaghimi; Mary Leigh Wolfe; Chenming Zhang;

Associate Professors: Zachary Easton; Leigh Anne Krometis; Jactone Ogejo;

David Sample; Durelle Scott; Ryan Senger; Venkataramana Sridhar; Theresa

Thompson;

Assistant Professors: Juhong Chen; Jonathan Czuba; Julie Shortridge; Robert

Wright;

H.E. and Elizabeth F. Alphin Professor: Saied Mostaghimi;

General Contact: lizaas14@vt.edu

Graduate Site: <https://www.bse.vt.edu/graduate.html>

Biological Systems Engineering (BSE) is the engineering discipline that applies concepts of biology, chemistry and physics, along with engineering science and design principles, to solve problems in biological systems. The mission of the Biological Systems Engineering Department is to develop and disseminate engineering knowledge and practices that protect natural resources and improve sustainable production, processing, and utilization of biological materials. Our faculty and students work in a broad range of biological systems, from natural systems, such as watersheds with a focus on water resources, to built systems, such as bioreactors and bioprocessing facilities. We work from the nanoscale to the macroscale. We seek to improve animal, human, and environmental health through development and design of healthy food products, vaccines, bioenergy, biomaterials, and water quality

management practices. We convert biological resources, such as switchgrass, plant proteins, and animal manure, into value-added products, such as biopharmaceuticals, biofuels, and biomaterials, in a sustainable manner.

SPECIAL FACILITIES

Information about the following facilities is available on our web site:

Facilities

Bionanotechnology Laboratory
Bioreseparation Laboratory
BSE Pilot Laboratory
Byproduct Management Laboratory
Ecological Engineering Laboratory
Environmental Processes Laboratory
Fluvial Processes Laboratory
Food Processes Laboratory
Hydroecology Laboratory
Metabolic Engineering and Renewable Materials Laboratory
Plant Synthetic Biology Laboratory
Prices Fork Research Facility
Sediment Laboratory
STREAM Lab
Water Microbiology Laboratory
Water Quality Laboratory
Water Systems Modeling Laboratory
Watershed Assessment Laboratory
Watershed Monitoring Laboratory

DEGREES OFFERED

MS Degree

Offered In (Blacksburg)

TOEFL

Paper: (550.0)

Computer: (213.0)

iBT: (90.0)

GRE

General Test: Verbal, Quantitative, Analytical

Master of Science - Thesis (MS)The Department offers the MS degree with a thesis option. For a thesis option, the student in the MS program will conduct independent research and will produce a thesis and defend the research findings for fulfilling the requirements of the degree. A minimum of 30 total credits (24 course credits) are required.

MEng Degree

Offered In (Blacksburg)

TOEFL

Paper: (550.0)

Computer: (213.0)

iBT: (90.0)

GRE

General Test: Verbal, Quantitative, Analytical

Master of Engineering (ME)The ME degree is a non-thesis course of study designed for those who are interested in broadening their general knowledge of Biological Systems Engineering, rather than specializing in one specific area. Although a thesis is not required for this degree program, the students are required to complete a project report. Thirty credit hours, including 3 to 6 credit hours of Project and Report are required. This degree is not recommended for students who might be

interested in pursuing a PhD degree. The students in a ME program are not eligible to receive research assistantships from the Department.

PhD Degree

Offered In (Blacksburg)

TOEFL

Paper: (550.0)

Computer: (213.0)

iBT: (90.0)

GRE

General Test: Verbal, Quantitative, Analytical

PhD (post-MS) This option is for students who already have an MS degree and would like to continue their academic career in order to receive a PhD. The PhD is the highest academic degree awarded by the University and is conferred upon a student who demonstrates outstanding original scholarship during advanced study. It signifies that the student is able to conduct independent research and has both a broad basic knowledge of all areas of the field and a comprehensive knowledge of one area. A student who wishes to qualify for the degree is expected to meet the requirements of both the Graduate School and the Department. Direct PhD The Direct Admit to PhD (Direct PhD) program is for exceptional students with research experience who have a BS degree and want to be admitted to the Direct PhD Program without completing an MS degree. These students should have excellent academic records with a minimum grade point average of 3.5 (for the last 60 credit hours) and should be able to provide evidence of research activities to indicate their ability to synthesize information and conduct research experiments. Annual evaluations of the Direct PhD students will be conducted by the Graduate Committee and the student's Advisory Committee. If it is determined that the student does not possess the ability to successfully complete a PhD degree, the Advisory Committee and the Department would consider awarding a non-thesis MS degree, provided that all university requirements for this degree are met by the student. Successful students will proceed with their program and follow all Departmental policies and procedures established for the PhD program.

GRADUATE COURSES (BSE)

BSE 5044 (BMES 5044) (CHE 5044):

Engineering Mathematics

Introduction to numerical solutions of partial differential equations using the finite element method in one-, two-, and three-dimensions with direct relevance to chemical engineering, biological systems engineering and biomedical engineering and sciences. Partial differential equations and ordinary differential equations using finite differences, model parameter sensitivity analysis, optimization, and data analysis. Pre-requisite:

Graduate Standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

BSE 5214:

Advanced Topics in Watershed Management

An interdisciplinary exploration of advanced topics in watershed management. Reading, discussion, summary and presentation of current research in the areas of water quality and watershed management.

Topics will be built around a semester theme that will vary by semester; the course may be repeated up to three times. Graduate standing required.

Credit Hour(s): 2

Lecture Hour(s): 2

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

BSE 5224G:

Advanced Field Methods in Hydrology

Site characterization: surveying, channel and floodplain mapping, land use, electronic data acquisition. Techniques for measuring surface and subsurface hydrological processes: water flow, hydrologic conductivity, precipitation, evaporation. Sampling techniques: surface water, groundwater, and soil pore water sampling. In-situ monitoring: automatic samplers, dataloggers, water quality sondes. Laboratory analyses: GLP practices, selection of analytical method, calibration, QA/QC. Pre:

Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 2

Instruction Type(s): Lab, Lecture, Online Lecture

Instruction Type(s): Lab, Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

BSE 5244 (CEE 5244):

Advanced GIS in Hydrologic Analysis

Advanced GIS course focusing on raster analysis with particular application to the issues associated with hydrologic analysis. Application and evaluation of algorithms for terrain analysis, watershed characterization, and hydrologic analysis and modeling as implemented in GIS. Digital elevation data sources and error assessment. Approaches to GIS/model integration and application.

Credit Hour(s): 3

Lecture Hour(s): 2

Instruction Type(s): Lab, Lecture, Online Lecture

274 Instruction Type(s): Lab, Lecture, Online Lecture

Prerequisite(s): BSE 4344 (UG) OR CEE 5204 (UG) OR GEOG 4084 (UG), BSE 3305 (UG) OR CEE 4304 (UG)

Corequisite(s):

BSE 5304G:

Advanced Watershed Modeling

Fundamental modeling principles used to quantify watershed hydrology, energy budgets, and associated ecosystem functions, such as plant dynamics and biogeochemical processes, at scales ranging from soil pores to watersheds. Code development and model integration to simulate watershed hydrology and nutrient and sediment transport.

Model calibration and performance assessment. Data discovery, acquisition, and processing of data relevant to hydrologic/watershed modeling. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 2

Instruction Type(s): Lab, Lecture, VB, Online Lecture

Instruction Type(s): Lab, Lecture, VB, Online Lecture

Prerequisite(s):

Corequisite(s):

BSE 5344G:

Applied Geographic Information Systems

Conceptual, technical, and operational aspects of geographic information systems as a tool for storage, analysis, and presentation of spatial information. Focus on engineering applications in resource management, site selection, and network analysis. Laboratory work required. Graduate standing required.

Credit Hour(s): 0 OR 3

Lecture Hour(s): 0 OR 2

Instruction Type(s): Lab, Lecture, Online Lecture

Instruction Type(s): Lab, Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

BSE 5364:

Stream Restoration

Stream restoration practices related to channel dynamics, sediment transport, impact of human activities, aquatic habitat improvements, and design and assessment. Inspecting, classifying, identifying and measuring river features of channel morphology to predict river reaction to human activities and watershed change. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 2

Instruction Type(s): Lab, Lecture, Online Lecture

Instruction Type(s): Lab, Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

BSE 5404:

Agricultural Nonpoint Source Pollution

Assessment and management of agricultural nonpoint source pollution (NPS). Precipitation, runoff, erosion, pollutant fate and transport, and best management practices. Application of Total Maximum Daily Loads and water quality standards. Pre: Background in physical, chemical, biological, and soil factors affecting the environment and in environmental regulations.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

BSE 5504G:

Adv. Bioprocess Engineering

Study of engineering concepts for biological conversion of raw materials to food, pharmaceuticals, fuels, and chemicals. Emphasis is placed on enzyme kinetics and technology, bioreaction kinetics, design, analysis, and control of bioreactors and fermenters, and downstream processing of bioreaction products. Graduate Standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

BSE 5544G:

Advanced Protein Separation Engineering

Concepts, principles and applications of various unit operations used in protein separations. Properties of biological materials, such as cells and proteins, and their influences on process design. Design of processes for protein purification based on the impurities to be eliminated. Concepts and principles of scale-up of unit operations. Case studies in practical protein recovery and purification issues, with a focus on enhanced protein purification by genetic engineering. Protein purification process simulation and optimization using process simulation software. Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

275 Prerequisite(s): BSE 3504 (UG) OR BSE 3504 OR CHE 3144 (UG) OR

CHE 3144

Corequisite(s):

BSE 5564G:

Advanced Metabolic Engineering

Engineering concepts for analyzing, designing, and modifying metabolic pathways to convert raw materials to food, pharmaceuticals, fuels and chemicals. Cell metabolism, pathway design, bioenergetics, regulatory mechanisms, metabolic modeling, and genetic tools. Pre: Graduate Standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

BSE 5614:

Advances in Recombinant Protein Production

Concepts, principles and applications of various expression systems for protein and enzyme production, and the principles and applications of the most current unit operations used in bioseparations. Principles and applications of various methods for protein molecular modification to facilitate its downstream processing. Protein engineering by directed evolution and rational design. Mutant selection and identifications, and establishment of mutant library for protein expression. In vitro synthetic enzymatic biosystems for biomanufacturing. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

BSE 5624:

Enzyme Engineering

Latest advances in industrial applications of enzymes, kinetic models on solid substrates, protein engineering tools (rational design and directed evolution), and cell-free synthetic enzymatic pathway biotransformations for the production of biofuels and bioelectricity. Pre-requisite: Graduate Standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

BSE 5644:

Biobased Ind Polymers

Importance of biological feedstocks (i.e., proteins, polysaccharides, and fats) to industrial polymers and the future economy. Chemistry and processing of biological feedstocks into polymers. Properties of biobased polymers. Pre-requisites: Graduate Standing and Knowledge of thermodynamics, transport phenomena, and organic chemistry required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

BSE 5894:

Final Examination

NONE

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

BSE 5904:

Project and Report

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research, Online Research

Instruction Type(s): Research, Online Research

Prerequisite(s):

Corequisite(s):

BSE 5944:

Seminar

Selected presentations and discussions by graduate students and faculty.

Credit Hour(s): 1

Lecture Hour(s): 1

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

BSE 5954:**Study Abroad**

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

BSE 5974:**Independent Study**

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Independent Study, VI

Instruction Type(s): Independent Study, VI

Prerequisite(s):

Corequisite(s):

BSE 5984:**Special Study**

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

BSE 5994:**Research and Thesis**

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research, Online Research

Instruction Type(s): Research, Online Research

Prerequisite(s):

Corequisite(s):

BSE 7994:**Research and Dissertation**

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research, Online Research

Instruction Type(s): Research, Online Research

Prerequisite(s):

Corequisite(s):

CHEMICAL ENGINEERING

David Cox, Head

Professors: Luke Achenie; Donald Baird; David Cox; Richey Davis; William Ducker; Erdogan Kiran; Yih-An Liu; Chang Lu; Padmavathy Rajagopalan;**Associate Professors:** Aaron Goldstein; Ayman Karim; Stephen Martin; Abby Whittington;**Assistant Professors:** Michael Bortner; Sanket Deshmukh; Rong Tong; Hongliang Xin; Huiyuan Zhu;**Alexander F. Giacco Professor:** Donald Baird;**Frank C. Vilbrandt Professor:** Yih-An Liu;**Robert E. Hord, Jr. Professor:** Padmavathy Rajagopalan;**Fred W. Bull Professor:** Chang Lu;**Graduate Coordinator:** dianec@vt.edu**Graduate Chair:** wducker@vt.edu**Department Head:** dfcox@vt.edu**Department Site:** <http://www.che.vt.edu>

Overview of ChE Graduate Program Chemical engineering has and will continue to play a prominent role in all realistic solutions to national and international problems of energy, the environment, health, and food. Progress toward solutions in these areas rests with judicious application of science. Such is the domain of the chemical engineer. The graduate plans of study in chemical engineering are heavily oriented toward synthesis as well as the usual emphasis upon analysis. There is a strong thread of physics, chemistry, mathematics, biochemistry, and microbiology in much of the research in the department. Active research areas include polymer chemistry, polymer science and engineering, colloid and surface chemistry, solid state chemistry and physics, nanotechnology, applied thermodynamics, molecular modeling, biochemical and tissue engineering, biomaterials, nanomedicine, catalysis and surface science, design for sustainability, green engineering, computer-aided design, and supercritical fluid science and technology. This representative list of topics gives an indication of the breadth and diversity of research areas in the department. Programs are also available for students with undergraduate degrees other than chemical engineering. Chemistry majors, especially those with thorough backgrounds in physical chemistry and mathematics, as well as graduates in biochemistry and microbiology, can re-orient their studies. The applied science nature of the research in the department facilitates this reorientation process for such students. Ph.D. programs to meet the needs of these students generally may require additional courses. The Ph.D. and M.S. degrees include a core of 14 credits in transport phenomena, thermodynamics, kinetics and mathematics. These courses are supplemented with electives chosen in support of the thesis research or the student's special interests. The Ph.D. is awarded only to those students who demonstrate the initiative and ability to carry through a significant research program, resulting in a thesis. A thesis is required of all M.S. degree students. Much of the research in the department

involves multidisciplinary efforts; as such, chemical engineering students develop strong interactions with students and faculty in and out of the department and across colleges.

SPECIAL FACILITIES

The Chemical Engineering Department has state-of-the-art experimental facilities for the chemical, physical and biological characterization of materials. Computational resources include a departmental cluster and campus-wide supercomputing facilities.

Bio-Nanomaterials Lab

Faculty: Prof. Richey Davis Research in this lab concerns the self-assembly of polymers at interfaces and the engineering of nanostructured particles for drug delivery and medical imaging applications. A major focus is on the formation and characterization of nanoparticles with well-defined size distributions and compositions. The therapeutic payloads contained in the nanoparticles include small molecule drugs, peptides, and DNA. Imaging agents contained in the nanoparticles are used for characterizing biodistribution and consist of fluorophores for optical imaging and superparamagnetic iron oxide particles for MRI. The lab is equipped with instrumentation to characterize the size distributions, surface chemistry, compositions, and related properties of nanoparticles.

Catalysis, Nanomaterials and In Situ/Operando Characterization Lab

Faculty: Prof. Ayman Karim Our research is multidisciplinary in the areas of nanomaterials synthesis, in situ/operando characterization, and heterogeneous catalysis. In the nanomaterials synthesis area, work is directed at understanding the nucleation and growth mechanisms of colloidal nanoparticles with the aim to control their size, shape and composition. In the heterogeneous catalysis area, the work is focused on designing catalysts with molecularly tailored properties for biomass conversion, shale gas utilization and automotive exhaust emission applications. The use of microreactors and advanced in situ/operando characterization tools is the cornerstone of the research program and includes: spectroscopy (X-ray absorption and infrared), small angle X-ray scattering, transmission electron microscopy and others.

Colloidal and Surface Engineering Laboratory

Faculty: Prof. William Ducker This lab is focused on measuring the physical properties of colloidal particles and surface in liquids. State-of-the-art instruments are available for measuring rheology, zeta potential, particle size distribution, streaming potential, surface imaging (AFM, and fluorescence microscopy), adsorption (QCM, ATR-IR), and for handling bacterial suspensions. A major focus of the lab is understanding bacterial adsorption. The lab has facilities for BSL2 biosafety, and includes a biosafety cabinet and incubators.

Computational Catalysis Lab

Faculty: Prof. Hongliang Xin This lab focuses on understanding structure-function relationships of nanoscale materials for energy

applications with a multi-scale modeling framework that integrates our expertise in ab-initio calculations, kinetic simulations, and statistical learning.

Computational Materials Design Lab

Faculty: Prof. Sanket Deshmukh Our research group is interested in creating new materials and biomaterials promising for use in a number of technologically important areas, such as energy, biomedicine, and tribology. By coupling statistical mechanical theory and newly developed multi-scale computational models in the group, we improve the fundamental understanding of the structure-property relationships in the existing materials with the assistance from supercomputers. A deeper understanding of the atomic-level structure and dynamics of the existing materials and proximal solvent molecules empower us to design new hybrid materials with predefined structure and function that can be used in next generation devices.

Drug Delivery and Biomaterials Lab

Faculty: Prof. Rong Tong Our work is at the interface of chemistry, materials science, nanotechnology and biotechnology, with interests in the following areas: (1) polymers and materials chemistry, in particular biodegradable polyester; (2) polymer biomaterials, in particular polymeric nanoparticles for drug delivery; (3) controlled release delivery system, including on-demand drug delivery for cancer therapy.

Lab for Center of Excellence in Process System Engineering

Faculty: Prof. Y. A. Liu A computational lab supported by sponsors of our graduate research and industrial outreach in process system engineering, such as Aspen Technology, Inc., SINOPEC and PetroChina. Current research focus on energy-saving design, validation and applications of CO₂ capture and acid gas cleaning processes, adsorptive and chromatographic separations, polymer process modeling, monitoring, and advanced process control, big data analytics and machine learning in bioprocessing and chemical engineering.

Laboratory for Biomaterials and Tissue Engineering

Faculty: Prof. Padma Rajagopalan Research focuses on the development of model tissue constructs or functional tissue units and the study of cell-substratum interactions. A primary goal is to design tissue constructs that mimic the native structure of tissues in vivo and to systematically probe cellular response to a variety of cues. This involves the fabrication of biocompatible scaffolds and templates, and more importantly tailoring surface and bulk properties. Another research interest is to quantify cell-substratum interactions. Specifically studies focus on how chemical and mechanical properties of an underlying substratum affect cellular motility and contractility.

Membranes and Nanostructured Materials Laboratory

Faculty: Prof. Stephen Martin Research focuses on the synthesis, characterization and applications of soft and nanostructured materials, including surfactants, thin films, liquid crystals, liquid crystal polymers, block copolymers and nanocomposites. Particular emphasis is placed

on the relationships between structure in soft materials, materials processing, and control of material properties. Applications include membranes for gas, liquid, and chiral separations; functional and responsive surfaces; and polymer and nanocomposite processing. Specialized instrumentation in the lab includes equipment for X-ray Scattering (SAXS and WAXD), optical microscopy, spin coating, contact angle goniometry, liquid chromatography, gas chromatography, isothermal adsorption gravimetry, and gas and liquid permeation (single gas, mixed gas, membrane chromatography, and reverse osmosis.)

Microfluidics Lab

Faculty: Prof. Chang Lu Development of microfluidic devices for studying cells and biomolecules. Research also focuses on understanding microscale fluid mechanics.

Multiscale and Multiphysics Modeling Lab

Faculty: Prof. Luke Achenie This facility specializes in molecular to macro-scale modeling, data science and scientific computing. We use modeling techniques such as molecular dynamics, quantum mechanics, machine learning, agent-based modeling and differential equations (ordinary, partial and integral). There are applications to membranes, surfactants, oral drug delivery, chemical/reactive processes and biomedical problems of current interest. The facility has a medium size Beowulf style high performance computing environment.

Nano Energy and Environmental Catalysis Lab

Faculty: Prof. Huiyuan Zhu Our research interest primarily focuses on synthetic engineering of nanostructured catalysts with rationally designed interfacial architectures, including metal-metal, metal-oxide, metal-ligand and metal-inorganic support, to achieve desired catalytic properties for sustainable energy and environmental applications. We investigate the atomic-scale architectures and the accompanying electronic and geometric effects on catalysis for small molecule (O₂, CO₂, N₂, CO, CH₄, etc.) activation and conversion. Our research aims to address the ultimate scientific challenge as how to modulate the reaction pathway to actively and selectively convert small molecules in our atmosphere to commodity chemicals and fuels.

Polymer Rheology and Processing Lab

Faculty: Prof. Donald Baird This laboratory is equipped with devices for measuring the basic flow properties of polymeric fluids and their composites and small scale processing facilities for converting the fluids into useful materials. The basic flow properties are used in the design of processes for converting these fluids into materials with optimum performance and properties. Computing facilities are available for numerical simulation of polymer processing operations.

Polymer and Composites Materials Laboratory

Faculty: Prof. Michael Bortner The PCML focuses on polymer composite processing and resulting morphology and structure property relationships, spanning macro to nano-scale polymer composites. Core research areas include advanced manufacturing approaches for rapid

fabrication of carbon fiber based composites, process modeling and materials development for polymer based additive manufacturing, development of novel nanoscale interfacial/interphase characterization analyses in thermosetting polymer nanocomposites, and processing/applications of cellulose nanocrystals (CNCs). Specialized equipment includes high temperature (bed/melt), multi-material extrusion custom additive manufacturing machines; modulated DSC; DMA; capillary and microcapillary rheometers; FTIR + MCT, ATR; laboratory scale extrusion, ultra high T (2200°C) vacuum furnace, Instron loadframe (500N-50kN, various geometries), high energy ball milling, Zeiss stereoscope (motorized stage and ZEN z-stacking hardware/software).

Skeletal Tissue Engineering and Mechanobiology Lab

Faculty: Prof. Aaron Goldstein Research in this lab concerns the fabrication of biocompatible polymer scaffolds for the regeneration of bone, cartilage, tendon and ligament tissues. Our goal is to fabricate materials that can provide chemical, biochemical, mechanical, and topographic cues to guide stem cells to migrate, proliferate, and differentiate into various skeletal tissues. In addition, we are interested in constructing composite and spatially graded materials that could lead to the regeneration of heterogeneous tissues such as the bone-to-ligament transition. Finally, we are interested in understanding how mechanical stimuli (e.g., tensile strain, hydrodynamic shear) act in concert with biomaterial scaffolds to affect stem cell viability and expression of skeletal tissue phenotypes.

Supercritical Fluids and High Pressure Lab

Faculty: Prof. Erdogan Kiran This is a highly specialized laboratory for investigations of thermophysical properties of dense or supercritical fluids and fluid mixtures, and systems that incorporate ionic liquids at high pressures, up to 1000 bar at 200°C. The focus is on thermodynamic and kinetic aspects of miscibility and phase separation and transport properties of dense fluid mixtures with emphasis on applications for polymer formation, modification and processing. Polymer miscibility and phase equilibria, polymer crystallization, and morphological modifications, polymer foaming and generation of micro or nanoporous materials in supercritical fluid mixtures, and assessment of high pressure viscosity are among the active research areas.

Ultrahigh Vacuum Surface Science Lab

Faculty: Prof. David Cox Capabilities for chemical and structural characterization of solid surfaces and surface reactivity using photoemission, electron diffraction, and temperature programmed desorption experiments.

DEGREES OFFERED

MEng Degree
TOEFL

Computer: (213.0)

iBT: (90.0), (0.0)

GRE

General Test: Verbal, Quantitative, Analytical

MEng (Project & Report) - Total of 30 credit hours. minimum of 24 graded credit hours maximum of 6 credit hours of Project & Report (5904) may include maximum of 6 credits of 4000-level undergraduate course work all other graded course work must be 5000-level or higher and may include: 3 credits of seminar and a maximum of 9 credits total in 5974, 5984 and 6984 MEng (non-thesis) - Total of 30 credit hours. minimum of 30 graded credit hours may include a maximum of 6 credits of 4000-level undergraduate course work all other graded course work must be 5000-level or higher and may include: 3 credits of seminar and a maximum of 9 credits total in 5974, 5984 and 6984

PhD Degree

TOEFL

Paper: (550.0)

Computer: (213.0)

iBT: (80.0)

GRE

General Test: Verbal, Quantitative, Analytical

PhD - Total of 90 credit hours. minimum of 27 graded credit hours may include a maximum of 6 credits of 4000-level undergraduate course work all other graded course work must be 5000-level or higher and may include: 4 credits of seminar and a maximum of 18 credits total in 5974, 5984 and 6984 minimum of 30 credit hours of Research & Dissertation (7994)

MS Degree

TOEFL

Paper: (550.0)

Computer: (213.0)

iBT: (80.0)

GRE

General Test: Verbal, Quantitative, Analytical

MS (thesis) - Total of 30 credit hours. minimum of 20 graded credit hours may include a maximum of 6 credits of 4000-level undergraduate course work all other graded course work must be 5000-level or higher and may include: 3 credits of seminar and a maximum of 6 credits total in 5974, 5984 and 6984 minimum of 6 credit hours of Research & Thesis (5994)

GRADUATE COURSES (CHE)

CHE 5014 (MSE 5014) (CHEM 5014):

Communication Skills and Methods of Presentation

Methods and style to make effective technical and nontechnical presentations including blackboard presentations, overhead presentations, slide presentations, and research posters. Video

presentations with critiques.

Credit Hour(s): 1

Lecture Hour(s): 1

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CHE 5034:

Introduction to Polymer Materials

Homopolymerization, copolymerization, polymer, architecture, morphology, thermal transitions, vitrification, crystallization, polymer solutions, blends, thermodynamics of miscibility and phase behavior, and mechanisms and kinetics of pressure- or temperature- induced phase separation, formation of particles, fibers, porous matrices or scaffolds, and novel technologies employing modifications and processing in or with dense or supercritical fluids, or ionic liquids. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CHE 5044 (BSE 5044) (BMES 5044):

Engineering Mathematics

Introduction to numerical solutions of partial differential equations using the finite element method in one-, two-, and three-dimensions with direct relevance to chemical engineering, biological systems engineering and biomedical engineering and sciences. Partial differential equations and ordinary differential equations using finite differences, model parameter sensitivity analysis, optimization, and data analysis. Pre-requisite:

Graduate Standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CHE 5094:

Advanced Chemical Engineering Kinetics

Fundamental principles of chemical kinetics applied to the analysis and design of chemical reactors.

Credit Hour(s): 3

280 Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): CHE 3184

Corequisite(s):

CHE 5125:

Transport Phenomena

Fundamentals aspects of transport of mass and chemical reaction.

Application to complex chemical engineering problems. Advanced mathematical techniques, fundamental aspects of transport of mass, and chemical reaction. Application to complex chemical engineering problems.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): (CHE 3044 (UG), CHE 3144 (UG)) OR (CHE 3044, CHE 3144)

Corequisite(s):

CHE 5126:

Transport Phenomena

Fundamentals aspects of transport of mass and chemical reaction.

Application to complex chemical engineering problems. Advanced mathematical techniques, fundamental aspects of transport of mass, and chemical reaction. Application to complex chemical engineering problems.

Credit Hour(s): 2

Lecture Hour(s): 2

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): (CHE 3044 (UG), CHE 3144 (UG), CHE 5125 (UG)) OR (CHE 3044, CHE 3144, CHE 5125)

Corequisite(s):

CHE 5144:

Advanced Thermodynamics

Fundamentals of physical and chemical equilibria, statistical thermodynamics, and applications to situations of current special interest.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): CHE 2164 (UG)

Corequisite(s):

CHE 5214:

Polymeric Biomaterials

Topics include polymer design and processing, inflammatory responses to polymers, interaction of blood with polymeric materials, and the effect of mechanical, chemical, and surface properties of polymers on cells.

The culmination of this course will provide students with the knowledge to successfully design polymer-based biomaterials, drug-delivery devices, and bio-implants. Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CHE 5304 (BMES 5304):

Biological Transport Phenomena

The fundamental principles of mass transport phenomena will be introduced and applied to the characterization of transport behavior in biological systems (e.g., cell, tissues, organs, people). Topics will include active, passive, and convective molecular transport mechanisms. These fundamentals will be used to develop analytical and predictive models that describe phenomena such as oxygen transport, kidney function, systemic drug delivery, and design of extracorporeal devices. Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): (CHE 3114 (UG) OR CHE 3114), (CHE 3044 (UG) OR CHE 3044 OR CHE 3144 (UG) OR CHE 3144) OR (ME 3304 (UG) OR ME 3304, ME 3404 (UG) OR ME 3404)

Corequisite(s):

CHE 5304G:

Advanced Biological Transport Phenomena

Engineering analysis and predictive modeling of heat and mass transport in biological systems (e.g., tissues, organs, organisms, and biomedical devices). Examination of processes that involve conduction, convection, diffusion, generation/ consumption. Application of analytical and computational methods to solve differential equations that describe unsteady and/or multi-dimensional transport. Topics include oxygen transport, drug delivery, pharmacokinetic analysis, kidney function, blood perfusion, cryopreservation, and hyperthermia. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CHE 5334G:

Colloid and Interface Science

Properties and behavior of colloidal systems, primarily in liquid environments. Size characterization and description, Brownian motion, interparticle forces, dispersion stability, and experimental techniques for characterizing these systems. Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CHE 5544G:

Advanced Protein Separation Engineering

Concepts, principles and applications of various unit operations used in protein separations. Properties of biological materials, such as cells and proteins, and their influences on process design. Design of processes for protein purification based on the impurities to be eliminated. Concepts and principles of scale-up of unit operations. Case studies in practical protein recovery and purification issues, with a focus on enhanced protein purification by genetic engineering. Protein purification process simulation and optimization using process simulation software. Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): CHE 3144 (UG) OR BSE 3504 (UG)

Corequisite(s):

CHE 5564:

Non-Newtonian Fluid Mechanics

Development of fluid models which describe the mechanical response of non-Newtonian fluids. Use of these models with the basic equations of continuum mechanics is emphasized.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): CHE 3114 (UG) OR CHE 3114

Corequisite(s):

CHE 5904:

Project and Report

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research

Instruction Type(s): Research

Prerequisite(s):

Corequisite(s):

CHE 5944:

Chemical Engineering Seminar

This course is designed to improve a students ability to present formal seminars concerned with technical and nontechnical information.

Numerous presentations are given by each student enrolling in this class.

Credit Hour(s): 1

Lecture Hour(s): 1

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CHE 5974:

Independent Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Independent Study

Instruction Type(s): Independent Study

Prerequisite(s):

Corequisite(s):

CHE 5984:

Special Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CHE 5994:

Research and Thesis

NONE

Lecture Hour(s):
Instruction Type(s): Research
Instruction Type(s): Research
Prerequisite(s):
Corequisite(s):

CHE 7994:

Research and Dissertation

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):
Instruction Type(s): Research
Instruction Type(s): Research
Prerequisite(s):
Corequisite(s):

CIVIL ENGINEERING

Mark Widdowson, Head

Emeriti Faculty: Gregory Boardman; William Cox; J Duncan; William Easterling;
Antoine Hobeika; Siegfried Holzer; David Kibler; James Mitchell; Thomas Murray;
John Novak; Raymond Plaut; Clifford Randall; Kamal Rojiani; Dusan Teodorovic;
Michael Vorster; Richard Weyers; Jesus de la Garza;

Professors: Montasir Abbas; Thomas Brandon; Scott Case; Finley Charney;
Andrea Dietrich; Marc Edwards; Gerardo Flintsch; Daniel Gallagher; Michael
Garvin; Stanley Grant; Russell Green; Kevin Heaslip; Jennifer Irish; William
Knocke; Roberto Leon; John Little; Linsey Marr; Amy Pruden-Bagchi; Hesham
Rakha; Carin Roberts-Wollmann; Adrian Rodriguez-Marek; Sunil Sinha; Antonio
Trani; Peter Vikesland; Linbing Wang; Mark Widdowson;

Associate Professors: Matthew Eatherton; Kathleen Hancock; Erich Hester;
Ioannis Koutromanos; Nina Stark; Kyle Strom;

Assistant Professors: Alexander Brand; Hosein Foroutan; Matthew Hebdon;
Susan Hotle; Gabriel Isaacman-VanWertz; Eric Jacques; Farrokh Jazizadeh
Karimi; Landon Marston; Frederick Paige; Megan Rippy; Rodrigo Sarlo; Maryam
Shakiba; Earl Shealy; Zhiwu Wang; Alba Yerro Colom;

Associate Professor of Practice: Joseph Dove; Bryan Katz;

University Distinguished Professor: Marc Edwards;

Research Associate Professors: Adil Godrej;

Charles P. Lundsford Professor: Linsey Marr;

W. Thomas Rice Professor: Amy Pruden-Bagchi;

Samuel Reynolds Pritchard Professor: Hesham Rakha;

Nick Prillaman Professor: Peter Vikesland;

David H. Burrows Professor: Roberto Leon;

Assistant Professor of Practice: Robert Scardina; Claire White; Kevin Young;

Charles E. Via, Jr. Professor: John Little;

Research Assistant Professors: Siddharth Saksena;

Reynolds Metals Professor: Scott Case;

Graduate Contact: shmartin@vt.edu

Extended Campus Contact: shmartin@vt.edu

Graduate Student Policy Manual: <https://www.cee.vt.edu/wp-content/uploads/2019/07/Graduate-Policies-and-Procedures-Manual-Departmental.pdf>

Graduate Site: <https://www.cee.vt.edu/prospective-graduate-students/>

The Charles E. Via, Jr. Department of Civil and Environmental Engineering awards the Master of Science in civil engineering, the Master of Science in environmental engineering, the Master of Engineering in civil engineering, and the Doctor of Philosophy in civil engineering. A Master of Science degree in environmental sciences and engineering are also administered within the department. For the civil engineering degrees, students may emphasize one or more of 10 discipline areas available for graduate study within the Department: civil engineering materials, civil infrastructure engineering, construction engineering and management, environmental engineering, geospatial engineering, geotechnical engineering, sustainable land development engineering, water resources engineering, structural engineering, and transportation engineering. A minor may also be taken in one or more of the alternate branches of engineering or in an allied field, such as mathematics, engineering mechanics, chemistry, geology, or urban and regional studies. As part of a land-grant University, the department strives to provide a mix of applied and theoretical learning and research opportunities. Success at achieving these goals and in offering attractive graduate study opportunities can be measured by the fact that graduate programs have grown substantially over the past 15 years, while student qualifications have also improved. Today, the graduating classes typically include approximately 140 MS degrees, and 25 Ph.D. degrees. The graduate enrollment of approximately 340-375 on the main campus and about another 20 students at extended campuses make this program one of the largest in the Southeast. The department ranks in the top 10 civil engineering and environmental engineering programs in the United States. The department has 56 full-time and twenty emeritus faculty members many of whom actively engaged with the department. Three faculty are members of the National Academy of Engineering, one is a member of the National Academy of Science, two are members of the National Academy of Construction, and ten hold prestigious named professorships. Fifteen members of the faculty have been awarded Presidential Young Investigator, National Young Investigator, or CAREER awards from the National Science Foundation. Two have been awarded the prestigious PECASE Award and seven have been awarded the State Council of Higher Education for Virginia Outstanding Faculty Award. Faculty members within the department have received numerous national and regional awards for their teaching, research, scholarship and outreach activities. Financial resources are available to support graduate students via a variety of funding mechanisms. The department annually awards the full-time equivalent of more than 40 graduate teaching assistantship positions. In addition, annual research expenditures (averaging approximately \$15 million dollars) provide numerous opportunities for students to receive graduate research assistantships. Finally, the Via Endowment (established at \$5 million dollars in 1987, now valued at nearly \$15 million dollars) provides special funds for fellowships that support the highest quality M.S. and Ph.D. students (U.S. citizenship or permanent residency required for Via support) who pursue graduate studies in the department. The Via

Endowment also provides special stipend support for a select number of Ph.D. students who receive an opportunity to pursue classroom instruction each year. While the majority of the department's graduate activities occur in Blacksburg, there are also opportunities available in other areas of the Commonwealth of Virginia. Four full-time faculty, who specialize in Environmental & Water Resources Engineering are located at the Occoquan Watershed Monitoring Laboratory in Manassas, Virginia (northern part of the state). A number of environmental and water resources graduate students conduct research in the Hampton Roads area in association with adjunct faculty at the Hampton Roads Sanitation District.

SPECIAL FACILITIES

The CEE department has a wide range of facilities to support its teaching and research goals.

CEECL Computer Laboratory

This instructional lab provides multimedia equipment (Computer, VCR, ELMO, LT) for faculty/staff to instruct audiences in the use of installed engineering software. The podium allows an instructor to project two independent video signals simultaneously on two separate screens. The primary purpose of this room is instruction for CEE courses and special classes

Kelso Baker Environmental Hydraulics Lab

Baker Environmental Hydraulics Laboratory (BEHL) is a 3100 square ft floor area facility, housing several research flumes and a wide variety of advanced research instrumentation and hydraulic measurement systems. The laboratory is devoted to environmental hydraulics related research.

Materials Laboratory

The materials laboratory provides 7700 sq. ft. of research space and contains equipment for evaluation of the performance of concrete and asphalt. Concrete and concrete- making materials performance evaluation equipment include rapid and critical dilation freezing and thawing cabinets, a computer-driven microscopic air void analysis apparatus, corrosion rate measuring devices, state-of-the-art image analysis system, petrographic microscope, and facilities for wet chemical analysis.

Occoquan Monitoring Laboratory (Manassas, VA)

The Occoquan Watershed Monitoring Laboratory (OWML), Manassas, is responsible for making determinations in a number of areas critical to the ongoing management of water quality in the Occoquan watershed, situated on the southwestern periphery of the Virginia suburbs of Washington, D.C. The basin encompasses six political subdivisions, including portions of four counties, and the entire land area of two independent cities.

Potomac Aquifer Recharge Monitoring Laboratory

The PARML, Hampton, is responsible for making determinations in a number of areas critical to the ongoing management of water quality in the Potomac aquifer, situated in the Hampton Roads area of Southeast

Virginia. This work is in association with managed aquifer recharge associated with the \$1 billion SWIFT (Sustainable Water Initiative For Tomorrow) project.

Structures Laboratory

The Structures and Materials Research Facility is located on the campus of Virginia Tech. The laboratory provides the structural and materials faculty the necessary equipment to conduct performance evaluations of civil engineering materials, and to conduct experimental research utilizing full-scale structural components. A total of 27,000 sq. ft. of laboratory and office space is available.

Virginia Tech Transportation Institute (VTTI)

The Virginia Tech Transportation Institute (VTTI) continues to serve as Virginia Tech's largest university-level research center and is dedicated to conducting research to save lives, save time and save money in the transportation field by developing and using state-of-the-art tools, techniques, and technologies to solve transportation challenges. Its cutting-edge research is effecting significant change in public policies in the transportation domain on both the state and national levels.

W.C. English Geotechnical Research Laboratory

The W.C. English Geotechnical Research Laboratory is the most advanced of its kind in Virginia and the mid-Atlantic region. The \$1.1 million facility, located approximately one mile from campus, has spacious rooms, filled with specialized instrumentation. This laboratory boasts 6,100 square feet of research space.

DEGREES OFFERED

MS Degree

Offered In (Blacksburg, National Capital Region)

TOEFL

iBT: (90.0)

GRE

General Test: Verbal, Quantitative, Analytical

Please NOTE that at the National Capital Region campus, students are housed at the Occoquan Watershed Monitoring Laboratory (OWML), and while all graduate degree programs in CEE are available, the program area of focus within CEE is limited to the Environmental & Water Resources Engineering Program (EWR) at the NCR campus. Please see information about our graduate certificate programs in the certificate section of the Graduate Catalog. See Departmental Manual at: <https://www.cee.vt.edu/wp-content/uploads/2019/07/Graduate-Policies-and-Procedures-Manual-Departmental.pdf>

Degree Concentrations:

Program Area Concentrations

Blacksburg Campus: Construction Engineering and Management
Environmental and Water Resources Engineering
Geotechnical Engineering
Structural Engineering and Materials Transportation

Infrastructure and Systems Engineering National Capital Region:

Environmental and Water Resources Engineering - ONLY

Interdisciplinary Program Area Concentrations

Civil Infrastructure Engineering

MEng Degree

Offered In (Blacksburg)

TOEFL

iBT: (90.0)

GRE

General Test: Verbal, Quantitative, Analytical

See Departmental Manual at: <https://www.cee.vt.edu/wp-content/uploads/2019/07/Graduate-Policies-and-Procedures-Manual-Departmental.pdf>

PhD Degree

Offered In (Blacksburg, National Capital Region)

TOEFL

iBT: (90.0)

GRE

General Test: Verbal, Quantitative, Analytical

Please NOTE that at the National Capital Region campus, students are housed at the Occoquan Watershed Monitoring Laboratory (OWML), and while all graduate degree programs in CEE are available, the program area of focus within CEE is limited to the Environmental & Water Resources Engineering Program (EWR) at the NCR campus. Please see information about our graduate certificate programs in the certificate section of the Graduate Catalog. See Departmental Manual at: <https://www.cee.vt.edu/wp-content/uploads/2019/07/Graduate-Policies-and-Procedures-Manual-Departmental.pdf> Program areas within CEE: Blacksburg Campus: Construction Engineering and Management Environmental and Water Resources Engineering Geotechnical Engineering Structural Engineering and Materials Transportation Infrastructure and Systems Engineering National Capital Region: Environmental and Water Resources Engineering - ONLY

GRADUATE COURSES (CEE)

CEE 5010:

Schedule Impact Analysis

Analysis of construction scheduling principles, scheduling specifications, contract administration, construction law, construction delay claims, and of accepted methodologies for performing schedule impact analysis of delaying events. Pre: Graduate Standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

CEE 5014:

Facility Delivery & Financing

Delivery and financing of constructed facilities with an emphasis upon civil infrastructure systems. Design of project delivery systems to encourage best value, innovation, and private sector participation. Public-private partnership strategies and factors that contribute to success or failure. Fundamentals of project feasibility, evaluation, and finance. Case studies of large-scale infrastructure projects. Pre-requisite:

Graduate Standing required

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CEE 5024:

Contract Administration and Claims Resolution

This course provides students with a knowledge of the different types of contracts used in civil engineering construction. Contracts are viewed as documents which assign responsibilities and allocate risks and emphasis is placed on contract administration as the first step in reducing costs and easing the burden of dispute resolution. Techniques for quantifying and resolving claims are studied.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CEE 5060:

Built Environment Information Modeling and Processing

Introduction to technologies that enable virtual modeling and processing of the infrastructure project life cycle. Introduction to theory and application of Building and Civil Information Modeling (BIM and CIM), and their integrated practices for the architectural, engineering and construction industries. Pre: Graduate Standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CEE 5074:**Global Virtual Design and Construction**

Fundamental aspects of modern civil engineering project execution in virtual workspaces. Participation in team-based virtual design and construction project involving students from other domestic and international universities. Design of organizational and task model, integration with design and cost models, identification of interventions that improve scheduling. Strengthened ability to work collaboratively with individuals from different countries/cultures. Both theory and practice emphasized. Pre: Graduate Standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CEE 5080:**Infrastructure Asset Management**

Comprehensive systems approach to civil infrastructure system and strategic-level asset management with emphasis on municipal, highway, building, dam, and bridge infrastructure. Course will cover various aspects of strategic-level infrastructure asset management: systems thinking, needs assessment, information technology and GIS data management, risk and reliability engineering, multi-criteria decision making process, infrastructure sustainability and resiliency, and renewal engineering (repair, rehabilitation, and replacement). Graduate Standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CEE 5084:**Information Technology for Infrastructure and Environment Systems**

With the acceleration of the process of global revolution in science, engineering and technology led by information technology, the human society is in a gradual transition from an industrial society into an information society. As a new productivity with the greatest potential at the present age, information technology has undergone great development. The incessant innovation in technology has also urged people to make better use of it and apply advanced information technology to their own industry. In recent years, Information Technology

(IT) and Cyber Infrastructure has been transforming engineering and business practices in many sectors, resulting in efficiency gains and improved services for the client. The infrastructure industry has been slow to utilize information technology effectively and slower still to grasp the ways in which the multitude of design, calculation, specification, project management, asset management, sensor technology, database and data analysis software applications relate to each other. This course provides an overview of the range of Information Technology (IT) applications available to the civil and environmental professional throughout the life cycle of a project, from data collection and analysis through software, project management, environmental impact analysis, visualization, and infrastructure asset management. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

CEE 5094:**CII Best Practices**

Introduction to Construction Industry Institute (CII) Best Practices, including Front End Planning Zero Accident Techniques, Constructability, and Material Management that affects construction projects. Management influences on construction processes and critical issues. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CEE 5100:**Stormwater Treatment**

Stormwater quality. Basic traps, basins, and filters. Stormwater treatment. Basic vegetative control systems. Mechanistic role of wetland. Best management practices. Monitoring, sampling, analysis, and maintenance methods. Pre: Graduate Standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CEE 5104:**Environmental Chemistry**

Applied, environmental aspects of physical, organic, and inorganic chemistry; including applications in sanitary engineering of the phenomena of precipitation, complexation, buffering capacity, and chemical equilibria. Review of the nomenclature and properties of organic compounds.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CEE 5114:**Advanced Environmental Sustainability - A Systems Approach**

Advanced quantitative methods to evaluate environmental sustainability using a systems approach. Sustainability assessment frameworks, indicators of sustainable development, green-house gas emissions, renewable energy systems, whole-system design, economic systems and input- output techniques, system dynamics models, emergence and agent-based models. Emerging sustainability topics. Pre: Graduate Standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

CEE 5124:**Fundamentals of Environmental Toxicology**

Introduction to nomenclature, principles, and scope of environmental toxicology. The fate and effects of both organic and inorganic toxicants in the environment, in animals, and in various test systems.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): CEE 5104 (UG) OR CEE 5104

Corequisite(s):

CEE 5125:**Environmental Engineering Design**

5125: Design of wastewater treatment facilities for the reduction and elimination of organic and inorganic pollutants; 5126: Design of water treatment facilities for the production of potable waters from surface and

groundwater systems. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

CEE 5126:**Environmental Engineering Design**

5125: Design of wastewater treatment facilities for the reduction and elimination of organic and inorganic pollutants; 5126: Design of water treatment facilities for the production of potable waters from surface and groundwater systems.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CEE 5130 (ESM 5554):**Turbulence and Turbulent Flows**

Nature and origin of turbulence, turbulent transport of momentum and heat, the dynamics of turbulence, statistical description of turbulence and spectral analysis. Examples of turbulent flows, boundary layers.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CEE 5134:**Engineering Aspects of Water Quality**

The application of biological, chemical, and physical principles of water quality to engineering problems in surface waters. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

CEE 5144:**Unit Operations and Processes Laboratory**

Applied science aspects of water and waste treatment; advanced research techniques in analysis and treatment of water and wastes.

Credit Hour(s): 0 OR 3

Lecture Hour(s): 0 OR 1

Instruction Type(s): Lab, Lecture, Online Lecture

Instruction Type(s): Lab, Lecture, Online Lecture

Prerequisite(s): (CEE 5125 (UG) OR CEE 5126 (UG)) OR (CEE 5125 OR CEE 5126)

Corequisite(s):

CEE 5154:

Air Pollution Transport and Chemistry

Air pollutant emissions, transformation, transport, and fate. Global climate change, ozone chemistry, air pollution modeling, particle dynamics, and air quality management. Pre: Graduate Standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CEE 5164:

Environmental Biotechnology

Introduction to environmental biotechnologies for wastewater treatment. Fundamentals of environmental microbiology. Engineering principles for applying biotechnology to address environmental pollution control.

Advanced biotechnologies, membrane bioreactors, and algal bioreactors. Sustainable environmental remediation and protection. Pre: Graduate Standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CEE 5184:

Techniques for Environmental Analysis

An introductory course on techniques commonly utilized for analysis of environmental samples. Course will discuss gas and liquid chromatography, mass spectrometry, and atomic absorption spectroscopy, focusing on analysis of complex environmental samples.

Practical techniques and applications are emphasized, but sufficient theory is introduced to provide students with an understanding of the principles involved.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CEE 5194:

Environmental Engineering Microbiology

Roles of microorganisms in wastewater treatment, anaerobic digestion of municipal sludges, stream self-purification, and degradation of water quality in drinking-water systems. Disinfection of wastewater and drinking water to remove viruses, bacteria, and protozoa that cause waterborne disease.

Credit Hour(s): 0 OR 3

Lecture Hour(s): 0 OR 2

Instruction Type(s): Lab, Lecture, Online Lecture

Instruction Type(s): Lab, Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CEE 5204:

Gis Applications in Civil Engineering

Examination of data structures used in geographic information systems. Map projections and coordinate systems used in mapping. Database creation, maintenance, and integrity. Applications of GIS methods for solving civil engineering problems in land management and related areas.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CEE 5224:

Advanced GIS Applications in Civil and Environmental Engineering

This project based course deals with both vector and raster Geographic Information Systems (GIS), network analysis, tracking applications, hydrologic applications, spatial analysis, web databases, and linking GIS to models with programming, specifically in the civil and environmental engineering arena. Pre: Any introductory GIS course, including CEE 5204, GEOG 4084, or BSE 4344. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

288 Prerequisite(s):

Corequisite(s):

CEE 5244 (BSE 5244):

Advanced GIS in Hydrologic Analysis

Advanced GIS course focusing on raster analysis with particular application to the issues associated with hydrologic analysis. Application and evaluation of algorithms for terrain analysis, watershed characterization, and hydrologic analysis and modeling as implemented in GIS. Digital elevation data sources and error assessment. Approaches to GIS/model integration and application. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 2

Instruction Type(s): Lab, Lecture, Online Lecture

Instruction Type(s): Lab, Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

CEE 5254:

Municipal Engineering

Field of municipal engineering. Infrastructure, capital projects, financing, sustainability, disaster planning and response, and municipal plan review techniques. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CEE 5264:

Sustainable Land Development

Contemporary techniques for developing land while maintaining a focus on long-term sustainability. Smart location and linkage, neighborhood pattern and design, conceptual design, stormwater strategies, green buildings and energy. Development standards such as Leadership in Energy & Environmental Design (LEED) and Envision. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

CEE 5264G:

Advanced Air resources Engineering

Effects, regulation, sources, and control of air pollution. Application of

engineering calculations and models to estimate emissions, predict pollutant concentrations, and design pollution control equipment.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CEE 5274:

Land Development Design Projects

Analysis of land development projects. Land development industry, government policies and regulations, legal topics, engineering design, and construction practices. Site feasibility analysis, site planning, environmental compliance, conceptual layout, and ADA compliance. Design of major infrastructure systems. Use of computer aided drafting and design software. Design project. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CEE 5304:

Environmental Fluid Mechanics

The first part of the course will be devoted to basic concepts and equations of fluid motion. The remainder of the course will be concerned with the theory of incompressible viscous and inviscid fluids. Selected applications will be drawn from environmental and water resources topics. Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

CEE 5314:

River Mechanics and Sediment Transport

Sediment properties; critical stress; bed-form regimes in alluvial streams; depth-discharge relations for rivers; bed load and suspended load movement; river stability; flow in bends; river training. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

CEE 5324:

Advanced Hydrology

Applications of statistics to hydrology, floods, and droughts; flow generation models; mathematical models in physical hydrology; difference methods in flow routing; kinematic wave; evapo-transpiration; infiltration; and atmospheric processes. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

CEE 5334:

Analysis of Water Resources Systems

Introduction to quantitative hydrology. Diverse computational aspects within watersheds. Methods and models used to examine components of hydrologic cycle. Risk analysis and statistical probability in hydrology. Comprehensive models for watershed management and urban hydrology. Pre: Graduate Standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CEE 5344:

Surface Water-Groundwater Interaction

Interaction (exchange) of surface water with groundwater at watershed, reach, sediment-patch scales including bidirectional hyporheic flows. Focus on streams and rivers, consideration of lakes. Steady and unsteady exchange hydraulics including laminar and turbulent flows. Exchange benefits and engineering goals including heat transfer, nutrient processing, and contaminant attenuation. Engineering applications including conjunctive use of surface water and groundwater resources and impact of groundwater pumping on rivers. Field methods.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

CEE 5354 (GEOS 5814):

Numerical Modeling of Groundwater

Theory and practice of numerical techniques are developed and applied to fluid flow and transport in ground-water flow systems. Governing equations are formulated using FD and FE techniques with appropriate BCs and ICs. Additional topics include: model conceptualization and grid design in multidimensional systems; practical applications of numerical models including calibration, validation, and prediction; concepts and techniques of advective transport using particle tracking and dispersive transport. Introduction to MODFLOW, MODPATH, MT3D, and others. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

CEE 5364:

Water Law

Analysis of law for allocation of surface and groundwater supplies, legal controls over water quality alteration, public rights of water use, and drainage law. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

CEE 5374:

Dynamics Groundwater

The theory of dynamics of fluids in porous media; fluid and matrix properties; transport equations; boundary and initial value problems; flow of immiscible fluids; dispersion. Pre: Graduate Standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

CEE 5384:

Transport Processes in Waterways

Advanced treatment of the mechanics of open channel flow, including uniform flow, gradually varied flow, channel transitions, and unsteady

flow. Independent research project. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

CEE 5390:

Advanced Urban Water Sustainability

Climate change and the supply of freshwater. Coupled socio-hydrologic feedback loops (systems dynamics models) and implications for water systems resilience. Urban water transitions theory and the evolution of water systems through time. Water productivity. Stormwater capture and reuse, green stormwater infrastructure, and ecosystem services.

Decentralized water and wastewater treatment systems. Emphasis is placed on the social (equity), environmental, and technological context in which urban water systems operate. Advanced statistical computing is used to quantitatively explore urban water systems challenges. Pre:

Graduate Standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CEE 5400:

Design of Prestressed Concrete

Principles of prestressing applied to single and multiple span concrete beams, beams with composite slabs, and two-way slabs. Design of individual elements of prestressed concrete for allowable stresses, flexural strength and shear that satisfy industry standards. Pre: Graduate Standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CEE 5410:

Intermediate Reinforced Concrete Structures

Behavior and design of reinforced concrete structures subjected to gravity and lateral loads. Moment-curvature relationships for reinforced concrete beams with and without confinement. Collapse mechanisms and redistribution in continuous members. Development length, slender

columns, two-way floor systems, and combined shear and torsion. Pre: Graduate Standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CEE 5414:

Finite Element Analysis of Structures

Formulation of the finite element method and application to skeletal, plate, and shell structures. Study of mesh layout and refinement, convergence characteristics, and solution accuracy. Tests of element quality. Use of commercial finite element codes such as ABAQUS.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CEE 5420:

Computer Methods of Structural Analysis

Formulation of the matrix displacement method in a form suitable for program development. Application to trusses, continuous beams, grids, and frames. Incorporation of special features such as constraints, rigid ends, internal releases, and support settlements. Initiation and modification of existing programs on the personal computer. Pre:

Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CEE 5424:

Computer Analysis of Structures II

Extension of matrix displacement method to skeletal space structures: space trusses, space frames, and grids. Incorporation of special features such as nonglobal constraints, assemblies of different types of elements, thermal problems, substructuring, and buckling analysis. Development of well-structured programs on the mainframe and transfer to the personal computer. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

CEE 5424G:

Intermediate Design of Prestressed Concrete Structures

Principle of prestressing applied to concrete beams, slabs, and frames; design of individual elements and structural systems of prestressed concrete; precast construction and connection design. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

CEE 5430:

Intermediate Design of Steel Buildings

Design of major components in steel-framed buildings, including composite beams and slabs, beam-columns, and moment connections. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CEE 5434:

Design of Cold-formed Steel Structures

Behavior and design of cold-formed steel members. Strength of thin plate elements; flexural members; compression members, symmetric and non-symmetric; beam-columns; welded, bolted, and screw-fastened connections. Building systems that utilize cold-formed steel members. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

CEE 5440:

Instrumentation and Signal Processing for Civil Engineering Applications

Fundamental operating principles and implementation guidelines for instrumentation in civil engineering. Measurements for strain and load, acceleration, temperature, pressure. Data acquisition and signal processing concepts, sampling, filtering, and frequency domain analysis. Statistics, uncertainty analysis, and experimental methods applied to sensor measurements. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CEE 5444:

Stability of Structures

Methods of static structural stability analysis and their applications. Buckling of columns and frames. Energy method and approximate solutions. Elastic and inelastic behavior. Torsional and lateral buckling. Use of stability as structural design criterion. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

CEE 5450:

Forensic Struct Engineering

Cultural and technical basis for concepts of risk and failure, formal approaches to failure investigation, origins of natural and man-made disasters, the role of building codes, standard of care, ethical standards, community resiliency, and legal issues as related to forensic structural engineering. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CEE 5454:

Blast Resistant Design of Structures

Explosion sources and blast waves. Computation of blast load parameters. Single degree of freedom dynamic analysis of blast loaded components. Material behavior at high strain rates. Protective design and detailing of concrete and steel structures and non-structural components. Retrofitting and hardening of existing structures. Pre:

Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

CEE 5464:

Structural Dynamics and Earthquake Engineering

Earthquake-induced vibration of single- and multi-degree-of-freedom systems; application to frames and to shear and torsional buildings; response spectrum analysis; building codes; static and dynamic lateral force procedures; seismic resistance of steel and concrete building frames. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s): null null

CEE 5470:

Structural Design for Seismic Load Effects

Analysis and design of steel and reinforced concrete structures for seismic load effects. Fundamental principles of earthquake engineering, as rooted in seismic hazard analysis, inelastic behavior, and dynamic response. Application of these principles to the design and detailing of reinforced concrete and structural steel buildings. Building code requirements for seismic loading and seismic resistant design.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): CEE 5464

Corequisite(s):

CEE 5474:

Advanced Reinforced Concrete Design

Limit design concepts, yield-line methods, seismic considerations, and other advanced topics related to design of reinforced concrete structures. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

CEE 5474G:

Intermediate Reinforced Concrete Structures

Behavior and design of continuous reinforced concrete structures subjected to gravity and lateral loads. Application of computer programs to frame analysis and design of members. Development length, biaxial bending of columns, continuous one-way beams and slabs, two-way floor systems, torsion, footing, and cantilever retaining wall design problems. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

CEE 5480:

Steel Bridge Design

Design and analysis of primary bridge components including concrete decks, steel plate girders, and bracing members. Moving loads, and load combinations specific to bridges using current design codes. Fatigue and fracture limit states from repetitive vehicular loads. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CEE 5490:

Structural Mechanics

Mechanics of civil materials and structural components. Fundamentals of elasticity. Bending of beams, beam-columns, and thin plates. Energy methods for boundary value problems. Stability conditions. Failure criteria, introductory fracture mechanics, and plasticity theories. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CEE 5494:

Theory of structural reliability; reliability based designs, safety index, linear and nonlinear design equations, load and resistance factors, Level I, II and III formats, code formulations; systems reliability, bounds on reliability.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

CEE 5500:

Numerical Methods in Geotechnics

Numerical modeling of geotechnical systems. Numerical methods in geotechnics. Finite element method, formulation of boundary value problems, principles of coupled hydromechanical analysis. Structure and use of finite element software.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): CEE 5514

Corequisite(s):

CEE 5504:

Risk Analysis Geotechnical Engineering

Methods for risk analysis of complex systems. Basic concepts of probability and reliability applied to geotechnical engineering problems. Geostatistics concepts. Probabilistic seismic hazard analysis and performance based design. Computational tools and simulation methods. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CEE 5514:

Soil Behavior

Behavior of soil examined from a fundamental soil perspective. Review of methods of testing to define response; rationale for choosing shear strength and deformation parameters for soils for design applications. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

CEE 5524:

Advanced Soil Testing for Engineering Purposes

Methods of testing and analysis of soil for engineering properties including compressibility; strength in triaxial, simple, and direct shear; permeability; and stability. Pre: Graduate standing.

Credit Hour(s): 0 OR 3

Lecture Hour(s): 0 OR 1

Instruction Type(s): Lab, Lecture, Online Lecture

Instruction Type(s): Lab, Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

CEE 5534:

Foundation Engineering I

Behavior and design of retaining walls and shallow foundations. Earth pressures, bearing capacity, and settlement. Stress distribution and consolidation theories. Settlement of shallow foundations. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

CEE 5544:

Foundation Engineering II

Behavior and design of anchored bulkheads, excavation bracing, driven piles, drilled piers and buried structures. Effects of pile driving. Response of deep foundations to vertical and horizontal loads.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): CEE 5534 (UG) OR CEE 5534

Corequisite(s):

CEE 5554:

Soil and Site Improvement

Methods of soil and site improvement including design techniques for dewatering systems, grouting, reinforced earth, in-situ densification, stone columns, slurry trenches, and the use of geotextiles. Construction techniques for each system are described. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

CEE 5564:

Seepage and Earth Structures

Soil permeability and seepage through soils. Embankment design. Compaction, earth pressures and pressures in embankments. Slope stability analysis. Settlements and horizontal movements in embankments. Landslide stabilization.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): CEE 5514 (UG) OR CEE 5514

Corequisite(s):

CEE 5584:

Geotechnical Aspects of Earthquake Engineering

Causative mechanisms of earthquake, earthquake magnitudes, ground motion, effect of local soil conditions on motions. Response of soils to seismic loading, liquefaction phenomena and analysis of pore pressure development, laboratory and in-situ testing for seismic loading. Analysis and design of slopes, embankments, foundations, and earth retaining structures for seismic loading. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

CEE 5594:

Geological Engineering

Mechanical and hydraulic properties of rock masses; analysis and design of rock foundations, slopes, tunnels, and other forms of civil infrastructure; rock reinforcement. Pre: Graduate Standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CEE 5600:

Civil Infrastructure Systems Analysis

Systems analysis, modeling infrastructure systems by mathematical programming, measuring infrastructure systems performances, probabilistic analysis of infrastructure systems, multiple attribute decision making in infrastructure systems. Pre: Graduate standing in engineering is required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CEE 5604:

Traffic Characteristics and Flow

Driver, vehicle, and roadway characteristics; stochastic modeling of traffic processes including queueing theory, headway distributions, and gap acceptance; stream flow characteristics including car-following and multilane traffic models, roadway capacity and bottleneck analysis, network operations, and fuel consumption models. Pre: Graduate standing.

Credit Hour(s): 0 OR 3

Lecture Hour(s): 0 OR 2

Instruction Type(s): Lab, Lecture, Online Lecture

Instruction Type(s): Lab, Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

CEE 5610:

Advanced Mechanics of Composite Materials

Introduction to the deformation, stress, and strength analysis of continuous-fiber-polymer-matrix laminated composites. Fabrication, micromechanics of stiffness and expansional coefficients, classical lamination theory. Environmentally induced stresses. Computerized implementation and design. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CEE 5614:

Analysis of Air Transportation Systems

Planning, design and operation of aviation systems with computer aided design tools and computer simulation models. Airline airport operations

and practices and their effect in airport planning and design. Air cargo facilities planning and modeling. State-of-the-art computer simulation models used in aviation environmental planning and airspace modeling. Graduate standing in CE required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CEE 5620:

Transportation Network Analysis

Optimal paths in transportation networks, transportation network design, vehicle routing and scheduling, facility location problems, traffic flows on networks, traffic assignment problems.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CEE 5624:

Transportation and Land Use

Interaction between transportation and land use variables, including modeling requirements, impacts, and data needs within the context of good community planning and economic development; elements of transportation and land use that shape the quality of life in urban areas.

Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

CEE 5634:

Analysis and Planning of Mass Transit Systems

An overview of mass transit systems; transit system planning including demand and cost analysis and evaluation; transit system design including route design, scheduling, and fare policy; transit networks and marketing; para transit systems; future trends in mass transit. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

CEE 5640:

Highway Transportation Safety

Identification of highway safety problems and development of solutions. User characteristics and expectations, road audits, roadside hardware systems, safety enhancing treatments, standard traffic control devices, real-time information and control systems, work zone and railroad crossing treatments, older driver design concepts, traffic calming, designs for pedestrians and bikes, delineation and lighting principles, and advanced 3D/4D design concepts. Group and individual analyses of problems. Pre: Graduate standing in engineering is required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

CEE 5644:

Transportation Systems Planning

Advanced consideration of problems dealing with transportation systems as they affect the socio-economic development of cities, regions, and nations; the travel behavior of a populace; the location of economic activity; the use of land; and the allocation of resources. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

CEE 5650:

Freight Operations & Planning

Introduction to the operation of modal and intermodal freight facilities and operation. Types of freight movement and handling equipment, freight planning methods, and research. Freight as a multi-modal transportation system. Role of privately owned and operated freight movement on public sector transportation operations and decision making. Communication of impacts of freight movement. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CEE 5654:

Critical Issues in Transportation

Technological, societal, economic, political, environmental, health, and energy effects on planning, design, operation, and management of the transportation system. Modeling of complex interactions and causal relationships among current issues. Principles of optimization for design and operation of the five basic elements of transportation (vehicles, networks, terminals, controls, and system administration). Problem definition, objectives identification, model development, alternatives generation and evaluation, and reasoning process for transportation investment. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

CEE 5660:

Transportation Risk, Reliability & Security

Transportation risk assessment and computation; evacuation modeling; reliability analysis; infrastructure interdependency analysis; network impact assessment. Pre: Graduate Standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

CEE 5674:

Advanced Pavement Design

Methods used to characterize, stabilize, and specify pavement materials. Methods for rigid and flexible highway and airport pavement design and analysis. Load equivalence factor and specific design considerations related to environment and traffic characteristics. Pavement overlay design. Software for pavement design and analysis using various models. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

CEE 5684:

Rehabilitation of Transportation Structures

Identification of maintenance and rehabilitation needs for transportation structures such as bridges and pavements. Cost effective maintenance and rehabilitation methods. Consideration of bridge and pavement management systems.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CEE 5694:

Traffic Signal System Operation and Control

Traffic signal system control, with emphasis in arterial operation. Signal system design and operations, traffic simulation techniques, advanced traffic control strategies, and incorporation of surface street systems into Intelligent Transportation Systems (ITS). Hands on experience in signal system software and hardware. Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CEE 5704 (PHS 5704):

Drinking Water & Health

Drinking water contamination and associated health outcomes. Programs to improve safe water access. Viral, bacterial, protozoal, and helminthic pathogens. Heavy metals, pesticides, and other contaminants. Drinking water treatment and supply in rural areas. Study designs for health outcome assessment. Field-based intervention trials. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s): null null

CEE 5714:

Surface Water Quality Modeling

297 Use, analysis, and development of water quality models for lakes, rivers,

and estuaries. Emphasis on model calibration, verification, and post-audit analysis. Lab portion will develop and apply a eutrophication model for an estuary using existing data.

Credit Hour(s): 0 OR 3

Lecture Hour(s): 0 OR 2

Instruction Type(s): Lab, Lecture, VB, Online Lecture

Instruction Type(s): Lab, Lecture, VB, Online Lecture

Prerequisite(s):

Corequisite(s):

CEE 5724:

Environmental Monitoring and Sampling

Experimental design and sampling techniques for environmental analysis, including environmental monitoring techniques and statistical principles for planning monitoring locations and frequencies at environmental sites such as landfills, rivers, lakes, and the atmosphere. Development of monitoring strategy; examination of sampling techniques for various sample types.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s): CEE 5104

CEE 5734:

Urban Hydrology and Stormwater Management

Development of methods and numerical models for computing surface runoff from developing watersheds; hydraulics of combined sewer systems; urban non-point source pollutant load calculations and best-management practices; control strategies for regional stormwater management; detention basin design for control of urban floods and non-point source pollutants. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

CEE 5744:

Topics in Structural Steel Design

Calculation of stresses in steel members. Overall-local buckling interaction. Design of singly symmetrical and unsymmetrical columns and topics on flexural design, design of plate girders, bracing design, and design of framing connections. Pre: Graduate standing

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

CEE 5754:

Pavement and Bridge Infrastructure Management Systems

Management concepts used in civil infrastructure; planning, design, construction, maintenance, and rehabilitation of bridge and highway systems. Prioritization, optimization, and decision-making techniques. Life-cycle-cost prediction. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

CEE 5764:

Asphalt Technology

Origin, types and properties of bituminous materials and their use in civil engineering. Asphalt rheology. Theory behind technological processes and procedures for hot-mix asphalt including design philosophy, performance, and durability. Modern construction with bituminous materials; special mixtures, recycling, and additives. Pre: Graduate standing.

Credit Hour(s): 0 OR 3

Lecture Hour(s): 0 OR 2

Instruction Type(s): Lab, Lecture, Online Lecture

Instruction Type(s): Lab, Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

CEE 5774:

Hazardous Waste Management

Review of regulatory framework governing hazardous waste management. Characteristics of hazardous wastes. Fundamental physical, chemical, and biological principles applied to the design of treatment processes. Risk management. Case studies. Design project. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s): CEE 5104

CEE 5784:**Special Topics in Portland Cement Concrete**

Advanced tools and approaches for supporting more sustainable transportation infrastructure investment decisions by balancing technical, economic, environmental, and social objectives. Selection of sustainable materials, systems and management approaches. Mitigation and adaptation to climate change. Cost and environmental life-cycle assessment methods and tools pertaining to transportation systems.

Pre: Graduate standing.

Credit Hour(s): 0 OR 3

Lecture Hour(s): 0 OR 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

CEE 5794:**Environmental Engineering Principles**

Examines the basic physical, chemical, and microbiological principles that provide the foundation for environmental engineering. Illustrates how these principles are applied to solve a wide range of environmental problems. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s): CEE 5104

CEE 5804:**Engineering Ethics and the Public**

Moral obligations of engineers and scientists toward the publics they serve; responsible conduct of research; responsible conduct of practice; the responsibilities and risks of witnessing wrongdoing; the value of non-expert knowledge claims and the importance of listening to public stakeholders. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CEE 5814:**Structure-Sediment Interaction**

Scour processes at structure foundations in the coastal zone. Erosion

and undermining at port walls, pipelines, piers, jetties, breakwaters, artificial reefs. Foundations and moorings for nearshore renewable energy devices. Sediment remobilization and liquefaction as a consequence of cyclic loadings and extreme events. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CEE 5834:**Asphalt & Pavement Modeling**

Characterization of asphaltic concrete microstructure. Relations to macroscopic properties. Pavement performance modeling. Pre: Graduate Standing

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CEE 5844 (AOE 5844):**Ocean and Coastal Wave Mechanics**

Linear wave theory including boundary value problems, wave transformation in shallow waters, long waves, and engineering properties of waves. Introduction to nonlinear wave theories. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CEE 5854G:**Advanced Coastal Engineering**

Basic wave mechanics principles, surf-zone processes, littoral and sediment processes, shoreline features, astronomical tides, coastal hazards, and functional design of coastal structures. Field trips. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CEE 5864:

Coastal and Estuarine Morphodynamics

Sediment transport in marine environments, shoreline change, bedform evolution and morphodynamics, tidal inlet morphodynamics, barrier island processes, storm erosion, delta development, beach dynamics. Evolution of estuarine waterways and wetland systems. Pre: Graduate Standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CEE 5874:

Coastal and Marine Geotechnics

Geotechnical aspects of coastal and marine engineering. The coastal zone as a working environment. Geotechnical properties of beach and seafloor sediments, methods and processes for subaqueous and coastal site investigations, complementary techniques for investigation. In-situ survey strategies, planning and management. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CEE 5884:

Legal Aspects of Civil, Construction and Environmental Engineering

Analysis of relevant federal and state law (commercial law, contracts law, environmental law) in application to the design and construction of civil and/or environmental engineering projects, as well as water and wastewater treatment and management. Professional liability, risk management and environmental regulatory compliance issues. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CEE 5894:

Final Examination

NONE

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CEE 5904:

Project and Report

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research, Online Research

Instruction Type(s): Research, Online Research

Prerequisite(s):

Corequisite(s):

CEE 5944:

Seminar

Review and discussion of current literature, research, and consulting activities by student, faculty, and guest speakers.

Credit Hour(s): 1

Lecture Hour(s): 1

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CEE 5974:

Independent Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Independent Study, Online Lecture

Instruction Type(s): Independent Study, Online Lecture

Prerequisite(s):

Corequisite(s):

CEE 5984:

Special Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

300 Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CEE 5994:

Research and Thesis

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research, Online Research

Instruction Type(s): Research, Online Research

Prerequisite(s):

Corequisite(s):

CEE 6104:

Advanced Environmental Chemistry

Advanced theories and practices in environmental engineering with special emphasis on inorganic aspects of water chemistry; application of water chemistry fundamentals for the description of aquatic systems.

Pre: Graduate standing.

Credit Hour(s): 2

Lecture Hour(s): 2

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

CEE 6114:

Advanced Topics in Air Quality Engineering

Review and critique of current research. Emissions, transport, transformation, and fate of gases and particles in the atmosphere. May be repeated with different topic content for a maximum of 3 credits. Pre: Graduate standing.

Credit Hour(s): 1

Lecture Hour(s): 1

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

CEE 6404:

Dynamics of Structures

Formulation of equations of motion by the finite element method. Solution by mode superposition and direct methods. Earthquake analysis and nonlinear analysis. Application to skeletal and plate structures. Development of computer programs and use of commercial programs. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): (CEE 5414 (UG), ESM 4074 (UG)) OR (CEE 5414, ESM 4074)

Corequisite(s):

CEE 6414:

Nonlinear Finite Element Analysis for Solids and Structures

Nonlinearities encountered in solid and structural mechanics. Finite element formulation of nonlinear truss and beam problems. Nonlinear solid mechanics and plasticity theory. Algorithmic implementation of elasto-plastic constitutive models. Implicit and explicit solution procedures for finite element analysis of nonlinear static and dynamic problems.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): CEE 5414

Corequisite(s):

CEE 6424:

Advanced Prestressed Concrete

Behavior and design of prestressed slabs, bridges, and precast building systems. Continuous prestressing; load-balancing method for slabs; torsion and shear; connections for precast members; partial prestressing. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

CEE 6434:

Advanced Steel Design

Advanced topics of current interest in structural steel design research as given by recent publications and informal reports. In-depth study of selected projects. May be repeated. 12 credits of 5000-level courses in structures or solid mechanics required. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

CEE 6504:

Theoretical Soil Mechanics

Constitutive Laws for Soils, nonlinear elastic and plastic models.

Consolidation, layered systems, sand drains, approximate three-dimensional theories, and Biots poro-elastic formulation. Plastic equilibrium in soils Sokolovskis method of characteristics, applications to earth pressure, bearing capacity, and slope stability problems. Analysis of machine foundation problems, elastic waves through soils, dynamic properties of soils.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): CEE 5514 (UG) OR CEE 5514

Corequisite(s):

CEE 6514:

Dynamics of Soils and Foundations

Principles of the dynamics of soils and foundations. Seismic waves.

Non-linear dynamic soil behavior and vibrations. Dynamic-soil-structure interaction. Impedance functions and machine foundation design.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): CEE 5584

Corequisite(s):

CEE 6844:

Current Topics in Coastal Eng

Contemporary challenges and research questions in coastal engineering. Review and critique of contemporary coastal engineering literature. May be repeated with different topic content for a maximum of 6 credits.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): CEE 5854G

Corequisite(s):

CEE 6984:

Special Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CEE 7994:

Research and Dissertation

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research, Online Research

Instruction Type(s): Research, Online Research

Prerequisite(s):

Corequisite(s):

COMPUTER ENGINEERING

Luke Lester, Head

Emeriti Faculty: Robert Broadwater; Gary Brown; William Davis; Fred Lee;

Douglas Lindner; Arun Phadke; Krishnan Ramu; Warren Stutzman;

Professors: Amos Abbott; Masoud Agah; Paul Ampadu; Peter Athanas; Scott Bailey; Joseph Baker; Aloysius Beex; Dushan Boroyevich; Richard Buehrer;

Rolando Burgos; C Clauer; Gregory Earle; Dong Ha; Yiwei Hou; Michael Hsiao;

Mark Jones; Jih Lai; Luke Lester; Chen-Ching Liu; Thomas Martin; Scott Midkiff;

Lamine Mili; Khai Ngo; Mariusz Orlowski; Jung-Min Park; Paul Plassmann; Ting

Chung Poon; Saifur Rahman; Binoy Ravindran; Jeffrey Reed; John Ruohoniemi;

Walid Saad; Ahmad Safaai-Jazi; Timothy Sands; Wayne Scales; Leonard Smith;

Angelos Stavrou; Daniel Stilwell; Joseph Tront; Yue Wang; Anbo Wang; Yong Xu;

Jianhua Xuan; Yaling Yang;

Associate Professors: William Baumann; Virgilio Centeno; Jaime De La

Reelopez; Harpreet Singh Dhillon; Steven Ellingson; Louis Guido; Mantu Hudait;

Qiang Li; Lingjia Liu; Ali Mehrizi-Sani; Leyla Nazhandali; Cameron Patterson;

JoAnn Paul; Chris Wyatt; Yang Yi; Guoqiang Yu;

Assistant Professors: Thidapat Chantem; Christina Dimarino; Thinh Doan; Dong

Dong; Ryan Gerdes; Mona Ghassemi; Jia-Bin Huang; Xiaoting Jia; Ruoxi Jia; Ming

Jin; Vasileios Kekatos; Elena Lind; Majid Manteghi; Chang Woo Min; Ryan

Williams; Haibo Zeng; Yuhao Zhang; Wei Zhou; Yizheng Zhu;

Grant A. Dove Professor: Yue Wang;

Virginia Microelectronics Consortium Professor of Engineering: Masoud

Agah;

Bradley Distinguished Professor: Yiwei Hou;

James S. Tucker Professor: Jih Lai;

Willis Worcester Professor: Jeffrey Reed;

University Distinguished Professor: Dushan Boroyevich; Fred Lee; Arun

Phadke;

Clayton Ayre Professor: Anbo Wang;

Joseph R. Loring Professor: Saifur Rahman;

Bradley Faculty Fellow of Education: Thomas Martin;

J. Byron Maupin Professor of Engineering: Wayne Scales;

Elizabeth and James Turner Faculty Fellow: Harpreet Singh Dhillon;

Roanoke Electric Steel Professorship in Engineering: Luke Lester;

American Electric Power: Chen-Ching Liu;

Collegiate Assistant Professors: Almuatazbellah Boker; Kristie Cooper;

Collegiate Professors: Creed Jones; Vassilios Kovanis; Timothy Talty;

Collegiate Associate Professors: Jeffrey Ransbottom;

Research Professors: Scott Dunning;

Research Assistant Professors: Sook Ha; Mary Lanzerotti;

Graduate Admissions: vt.ece.gradadm@vt.edu

Graduate Counseling: eceadvising@vt.edu

NCR Graduate Coordinator: roxpaul@vt.edu

Student Handbook: <http://www.ece.vt.edu/gradman/manual.php>

The Harry Lynde Bradley Department of Electrical and Computer Engineering offers graduate degree programs leading to the Master of Engineering (M.Eng.), Master of Science (M.S.), and Doctor of Philosophy (Ph.D.) in electrical engineering and computer engineering. All degree programs are offered through the Blacksburg campus as well as extended campus consortia (National Capital Region, Northern Virginia Center, Falls Church, Virginia; Central; Hampton Roads; Western, and VT-MENA through Alexandria and Cairo, Egypt). For the master's degree, each plan of study, developed by the student in consultation with his or her faculty advisor, must contain a limited number of core courses. The M.S. degree program requires a thesis. The M.Eng. is a non-thesis degree program and is especially suitable for part-time graduate students employed as engineers by industry and government agencies. The Ph.D. degree program is research-oriented. Applicants applying for these degrees program must have an earned Master's degree in CPE, EE or related field. A direct-Ph.D. option is available for students without an earned Master's degree. These students will earn a Master of Science, Thesis, or Master of Science, Non-Thesis, degree in addition to the Ph.D. The Bradley Department of Electrical and Computer Engineering's current enrollment is approximately 535 students. Out of the enrolled students, approximately 95% of our full-time Ph.D. students are funded and approximately 75% of our full-time Master's student are funded. Funding is available in three ways: Graduate Teaching Assistantships - Awarded by the department Graduate Research Assistantships - Awarded by individual faculty Fellowships - Awarded by the department to the top applicants to the program. Of the fellowships awarded by the department, the Bradley Fellowship is the highest honor bestowed on ECE Ph.D. students and is restricted to U.S. citizens only.

SPECIAL FACILITIES

Well-equipped research facilities, labs, and centers are available within the different research areas. For more information, click here.

DEGREES OFFERED

MEng Degree

TOEFL

Paper: (590.0)

Computer: (243.0)

iBT: (96.0)

GRE

General Test: Verbal (153.0), Quantitative (157.0), Writing (4.5)

IELTS

General: Band (7.5)

32 credit hours 27 credit hours of course work 3 credit hours of project and report 2 credit hours of seminar The ECE Graduate Student Policy Manual gives detailed information pertaining to degree requirements.

MS Degree

TOEFL

Paper: (590.0)

Computer: (243.0)

iBT: (96.0)

GRE

General Test: Verbal (153.0), Quantitative (157.0), Writing (4.5)

IELTS

General: Band (7.5)

32 credit hours 21 credit hours of course work 9 credit hours of research and thesis 2 credit hours of seminar The ECE Graduate Student Policy Manual gives detailed information pertaining to degree requirements.

PhD Degree

TOEFL

Paper: (590.0)

iBT: (96.0)

GRE

General: Verbal (153.0), Quantitative (157.0), Analytical (4.5)

Regular PhD Requirements (for students with an earned Masters):92 credit hours 30 credit hours of course work 60 credit hours of research and thesis 2 credit hours of seminar Direct-PhD Requirements (for students with only an earned Bachelors):MS, Thesis and PhD - 92 credit hours 21 credit hours of coursework for MS (all transfer to PhD) 9 additional credit hours of coursework for PhD 9 hours of research and thesis for MS 60 credit hours of research and dissertation for PhD 2 credit of seminar that will count for both MS and PhD MS, Non-Thesis and PhD - 92 credit hours 30 credit hours of coursework for MS (all transfer to PhD) 60 credit hours of research and dissertation for PhD 2 credit of seminar that will count for both MS and PhD The ECE Graduate Student Policy Manual gives detailed information pertaining to degree requirements.

GRADUATE COURSES (ECE)

ECE 5104G:

Advanced Microwave and RF Engineering

Passive and active RF and microwave components and circuits for wireless communications: transmission-line theory; planar transmission-lines and waveguides; S-parameters; resonators; power dividers and couplers; microwave filters; sources, detectors, and active devices; modern RF & microwave CAD. Active RF components. Microwave amplifier design. Microwave Integrated Circuits (MIC). RF Microelectromechanical System (MEMS) components. Microwave systems. RF components for wireless systems. RF components for Ultra Wide band (UWB) systems. Prerequisite: Graduate Standing required

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ECE 5105:

Electromagnetic Waves

5105: Fundamentals of plane wave propagation, reflection, and transmission; basic theorems, equivalent currents, and Greens theory; radiation fields generated by current sources. 5106: Electromagnetic fields in the presence of inhomogeneous media; separation of variables; analyses of waveguide, cavity, radiation, and scattering problems; numerical methods. Pre: 5105: Graduate standing; 5106: 5105.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

ECE 5106:

Electromagnetic Waves

5105: Fundamentals of plane wave propagation, reflection, and transmission; basic theorems, equivalent currents, and Greens theory; radiation fields generated by current sources. 5106: Electromagnetic fields in the presence of inhomogeneous media; separation of variables; analyses of waveguide, cavity, radiation, and scattering problems; numerical methods. Pre: 5105: Graduate standing; 5106: 5105.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECE 5105

Corequisite(s):

ECE 5134G:

Advanced Fiber Optics and Applications

Theory of optical fiber waveguide propagation and design applications in communication and sensing systems. Pre-requisite: Graduate Standing required

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ECE 5144:

Introduction to Electro-Optics

Physical optics, wave propagation in inhomogeneous media, acousto-optic and electro-optic effects and their applications in intensity modulation and phase modulation of laser beams. Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): (ECE 3106 (UG), ECE 3614 (UG)) OR (ECE 3106, ECE 3614)

Corequisite(s):

ECE 5164 (AOE 5654):

Introduction to Space Science I: The Solar Wind and Magnetosphere

Describes the space environment from the sun to the earth's upper atmosphere. Fundamental concepts in space plasma physics will be presented, as needed, throughout the course. Numerous examples of observations and data will be utilized to illustrate the environment and its dynamic variability. An emphasis will be placed on the practical impacts of this environment and its dynamic variability. An emphasis will be placed on the practical impacts of this environment (space weather) on modern technologies such as solid state devices, satellite technology, communication and global navigation systems.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECE 3106 (UG) OR ECE 3106

Corequisite(s): ECE 5105

ECE 5174 (AOE 5174):

Introduction to Plasma Science

304 Underlying physical processes and basic computational techniques for

laboratory, space, and technological plasma environments including single particle motion, fluid and kinetic theory of plasmas, plasma waves and instabilities, diffusion and resistivity, and nonlinear effects. Pre:

Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ECE 5194:

Remote Sensing: Principles and Techniques

Physical principles involved in remote sensing of Earth's environment and their implementation in engineering systems; societal applications of remote sensing; fundamental principles of electromagnetic wave propagation and scattering; passive versus active techniques; remote sensing platforms and systems integration; advanced concepts important for the design and analysis of remote sensing engineering systems. Pre: Graduate Standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ECE 5200 (MSE 5200):

Semiconductor Alloys and Heterstructures

Advanced treatment of semiconductor materials with an emphasis on binary compounds, ternary and quaternary alloys, and strained-layer structures. Topics include crystal structure; lattice vibrations and phonons; energy band structure; equilibrium and non-equilibrium carrier distributions; electron and hole transport via diffusion and drift; and carrier generation and recombination mechanisms. Graduate standing required in the College of Engineering or College of Science.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): MSE 3204 (UG) OR ECE 4214 (UG) OR PHYS 3455 (UG) OR ECE 4214 OR MSE 3204 OR PHYS 3455

Corequisite(s):

ECE 5204:

Power Semiconductor Devices

Characteristics, fabrication, and application of power semiconductor

devices, which may include p-i-n and Schottky diodes, insulated gate bipolar transistors, field effect transistors, and thyristors. Effect of semiconductor material, device structure, and current injection levels on device performance. Device drive requirements and power circuit interaction. Implementation of power devices using wide band gap semiconductors such as silicon carbide and gallium nitride.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECE 5200

Corequisite(s):

ECE 5205:

Basic Semiconductor Devices

Description of the performance characteristics and limitations of basic semiconductor electronic devices in terms of the properties of semiconductor materials and device structure.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ECE 5210:

MicroElectroMechanical Systems: From Fabrication to Application

MicroElectroMechanical Systems (MEMS) are very-small systems or systems made of very small components. The course focuses on the design, fabrication, and application of microsystems providing a unique opportunity for interdisciplinary interactions. The course consists of lectures, readings from the current literature, discussion by students, and team-work projects. The major topics covered are: materials in MEMS; microfabrication techniques; sensing and actuating mechanisms; wafer-level packaging; and case-study of some MEMS-based devices and lab-on-a-chip systems. Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECE 4234 (UG) OR ECE 4234 OR BCHM 4124 (UG) OR BCHM 4124 OR CHE 4114 (UG) OR CHE 4114 OR CHEM 4124 (UG) OR CHEM 4124 OR ESM 4014 (UG) OR ESM 4014 OR ESM 4024 (UG) OR ESM 4024 OR ME 4304 (UG) OR ME 4304 OR ME 4404 (UG) OR ME 4404 OR MSE 4254 (UG) OR MSE 4254 OR MSE 4354 (UG) OR MSE 4354

Corequisite(s):

ECE 5220:**Radio Frequency Integrated Circuit Technology and Design**

Integrated circuit (IC) implementation of RF circuits for wireless communications applications. Transceiver architectures for current wireless communications standards; active/passive device technologies for RFIC implementations; low noise amplifiers; mixers; frequency sources; power amplifiers; single-chip radios; and RFIC packaging and testing. Case studies of modern RFIC chip sets for current wireless communications standards are examined. The course involves circuit design at the IC level; modern RF/microwave CAD software will be used in conjunction with the course. Design of a wireless transceiver functional block component RFIC chip. Alternate years.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): (ECE 3204 (UG), ECE 3614 (UG)), (ECE 4605 (UG) OR ECE 4104 (UG)) OR (ECE 3204, ECE 3614), (ECE 4605 OR ECE 4104)

Corequisite(s):

ECE 5234:**Emi and Noise Reduction Techniques and Filter Design**

Theory and practice of electromagnetic interference (EMI) noise coupling; techniques for noise reduction; shielding, grounding and filtering. Limitations of circuit theory, parasitics in circuits and their physical origins, measurement of EMI to comply with government regulation. EMI problems and solutions to switching power supply applications. Design of EMI filter, magnetics design, eddy currents. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

ECE 5244:**Advanced Power Conversion Techniques**

High-frequency resonant, quasi-resonant, and multi-resonant power conversion techniques; zero-voltage and zero-current switching techniques in pulse-width modulation converters and inverters. Pulse-width modulation and frequency modulation; non-linear analysis techniques for resonant and soft-switching converters and inverters. Power factor correction rectifiers and distributed power systems.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECE 4224 (UG) OR ECE 4224

Corequisite(s):

ECE 5254:**Power Converter Modeling and Control**

Nonlinear modeling of power conversion circuit using discrete and average techniques analysis and design of voltage mode and current mode control; parallel module operation and system interactions; distributed power systems; time domain simulation and frequency domain measurement techniques.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECE 4224 (UG) OR ECE 4224

Corequisite(s):

ECE 5264:**Advanced Power Electronics Laboratory**

Study of advanced control and high frequency modeling of power converters; analysis and design of high-frequency power converters; analysis of high-frequency magnetic components; analysis and design of embedded power management solutions for distributed power systems.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECE 5254

Corequisite(s):

ECE 5274:**Modeling and Control of Three-Phase PWM Converters**

Power conversion principles for three-phase pulse-width modulation techniques, control and converters. Development of averaged models of three-phase rectifiers and inverters in stationary and rotating coordinates. Small-signal models in rotating coordinates and control design. Introduction of switching state vectors and different modulation schemes. Three-phase inverter and rectifier applications. Parallel and multi-level three-phase converters. Alternate years. Prerequisite or equivalent.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

306 Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECE 4224 (UG) OR ECE 4224

Corequisite(s):

ECE 5284:

Energy Harvest Circuit Design

Energy sources for energy harvesting. Equivalent circuits for various transducers including piezoelectric (PZT), electromagnetic generators, photovoltaic cells, and thermoelectric generators. Power management circuits (PMCs) and maximum power point tracking (MPPT) schemes for piezoelectric cantilevers. PMCs for electromagnetic and electrostatic generators, and photovoltaic modules. MPPT schemes for photovoltaic modules under full sun and partial shading. Pre: Graduate Standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ECE 5314:

Power System Operation and Control

A course dealing with modern power system operational and control problems and solution techniques. State estimation, contingency analysis, load-frequency control, and automatic generation control. Load flow analysis and external equivalents for steady-state operations.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECE 4334 (UG) OR ECE 4334

Corequisite(s):

ECE 5324:

Power System Planning

A study of generation planning, bulk power supply systems, production costing analysis, and load forecasting. Dispersed generation. Electric power system reliability and stability.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECE 4334 (UG) OR ECE 4334

Corequisite(s):

ECE 5334:

Electric Machines and Transients

Development of inductances, flux linkages, voltage equations, linear

transformations, continuous simulation techniques, and machine models.

Transients on transmission lines, transformers, and machines. Arcing and restriking phenomena. Lightning arresters and insulation coordination.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECE 4314 (UG) OR ECE 4314

Corequisite(s):

ECE 5374G:

Adv Alternate Energy Systems

Electric energy from alternative energy sources including solar, wind, hydro, biomass, geothermal and ocean. Characteristics of direct conversion, electromechanical conversion, and storage devices used in alternative energy systems. Power system issues associated with integration of small-scale energy sources into the electricity grid. System level cost benefit analysis. Prerequisite: Graduate Standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ECE 5414G:

Advanced Linux Kernel Programming

Design and internal organization of the Linux operating system kernel. Kernel subsystems, boot process, memory management, process and thread model, scheduling, interrupt and exception handling, virtual file system and the concrete file system, block I/O and I/O scheduler, network stack, and device drivers. Modification of existing kernel code. Design, implementation, test and evaluation of new kernel modules, Kernel and full software stack debugging techniques, and virtualization as an aid for operating system development and debug. Software engineering techniques to analyze, modify and run a large, complex open-source code base. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ECE 5424 (CS 5824):

Algorithms and principles involved in machine learning; focus on perception problems arising in computer vision, natural language processing and robotics; fundamentals of representing uncertainty, learning from data, supervised learning, ensemble methods, unsupervised learning, structured models, learning theory and reinforcement learning; design and analysis of machine perception systems; design and implementation of a technical project applied to real-world datasets (images, text, robotics). Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ECE 5434:

Cyber-Physical Systems

Modeling formalism of Cyber-Physical Systems (CPS). Modeling of physical and cyber systems; software synthesis from these modeling formalisms; supporting operating systems and hardware architectures for CPS; critical requirements of CPS and their validation/verification; and CPS case studies. Pre: Graduate Standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ECE 5444:

Advanced Technological Singularity

Investigation, conceptualization and analysis of Technological Singularity -- the potential impact of true artificial machine intelligence on engineering and society. Historical perspectives. Barriers to whole brain emulation and the engineering of superintelligence. The role of consciousness in achieving true machine intelligence. Potential scenarios if superintelligence would come into being. Pre: Graduate Standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ECE 5454:

Optimization Techniques for Electrical and Computer Engineering

Convex optimization theory and algorithms and their application to electrical and computer engineering. Sparse optimization methods, eigen-decomposition techniques, the expectation-maximizing algorithms, stochastic optimization techniques, and special techniques relevant to large-scale optimization.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECE 5605

Corequisite(s):

ECE 5480:

Cybersecurity and the Internet of Things

Cybersecurity principles and technologies motivated by the evolving ecosystem of Internet of Things (IoT): devices, operating systems, sensors, data storage, networking and communication protocols, and system services. IoT device and system security and privacy vulnerabilities, analysis, and attack mitigation techniques. Master of Information Technology (MIT) students only.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECE 5484 OR CS 5044

Corequisite(s):

ECE 5484:

Fundamentals of Computer Systems

Fundamental principles and concepts of computer systems. Computer hardware; Boolean logic; number systems and representation; design and operation of digital logic; analysis of instruction set architectures and computer organization; and specification of data communication and networking standards. Master of Information Technology (MIT) students only. Pre: Graduate Standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ECE 5485:

Networks and Protocols

5485: Fundamental principles and concepts of computer networks; application, transport, network, and data link protocols. Contemporary and emerging networks; Internet protocols. Principles of quality of

service, network security, and network management. 5486: Performance evaluation via analysis, simulation, and experimental methods of networks and network protocols. Wireless and mobile network technologies and protocols; wireless local area networks, cellular systems, sensor networks and the Internet of Things (IoT). Mobility in the Internet and application support for mobility. Master of Information Technology (MIT) students only. Partially duplicates ECE/CS 5565-5566.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECE 5484, CS 5044

Corequisite(s):

ECE 5486:

Networks and Protocols

5485: Fundamental principles and concepts of computer networks; application, transport, network, and data link protocols. Contemporary and emerging networks; Internet protocols. Principles of quality of service, network security, and network management. 5486: Performance evaluation via analysis, simulation, and experimental methods of networks and network protocols. Wireless and mobile network technologies and protocols; wireless local area networks, cellular systems, sensor networks and the Internet of Things (IoT). Mobility in the Internet and application support for mobility. Master of Information Technology (MIT) students only. Partially duplicates ECE/CS 5565-5566.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECE 5485

Corequisite(s):

ECE 5494:

Innovation Pathways in Artificial Intelligence and Machine Learning

Convergence of digital technologies in networked devices, big data, and advanced breakthroughs in artificial intelligence (AI) and machine learning (ML). Meaning, theory, and construction of socio-technical systems. Analysis of technical aspects and opportunities of AI/ML systems in organizations. Technosystem due diligence of advanced AI/ML systems. Assessment of the viability of emerging technological solutions. Social impacts of disruptive change upon individuals, organizations, and society-at-large. Frameworks for the design and implementation of advanced AI/ML systems. Planning for the future of AI/ML. Master of Information Technology (MIT) students only.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECE 5484 OR MGT 5804

Corequisite(s):

ECE 5504 (CS 5504):

Computer Architecture

Advanced computer architectures, focusing on multiprocessor systems and the principles of their design. Parallel computer models, programming and interconnection network properties, principles of scalable designs. Case studies and example applications of pipeline processors, interconnection networks, SIMD and MIMD processors.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECE 4504 (UG) OR ECE 4504

Corequisite(s):

ECE 5505:

Testing and Verification of Digital Systems

Various topics on digital circuit testing and verification. 5505: digital circuit testing including simulation, test pattern generation, design for testability, built-in-self-test, and diagnosis. Graduate standing in ECE is required. 5506: circuit verification including two-level and multi-level circuit verification, sequential circuit verification, model-checking simulation-based verification, and ATPG-based verification. Graduate standing in ECE required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECPE 4505

Corequisite(s):

ECE 5506:

Testing and Verification of Digital Systems

Various topics on digital circuit testing and verification. 5505: digital circuit testing including simulation, test pattern generation, design for testability, built-in-self-test, and diagnosis. 5506: circuit verification including two-level and multi-level circuit verification, sequential circuit verification, model-checking simulation-based verification, and ATPG-based verification. Graduate standing in ECE required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

309 Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECPE 4505

Corequisite(s):

ECE 5510 (CS 5510):

Multiprocessor Programming

Principle and practice of multiprocessor programming. Illustration of multiprocessor programming principles through the classical mutual exclusion problem, correctness properties of concurrency (e.g., linearizability), shared memory properties (e.g. register constructions), and synchronization primitives for implementing concurrent data structures (e.g., consensus protocols). Illustration of multiprocessor programming practice through programming patterns such as spin locks, monitor locks, the work-stealing paradigm and barriers. Discussion of concurrent data structures (e.g., concurrent linked lists, queues, stacks, hash maps, skiplists) through synchronization patterns ranging from coarse-grained locking to fine-grained locking to lock-free structures, atomic synchronization primitives, elimination, and transactional memory. Pre-requisite: Graduate Standing required

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECE 4534 OR ECE 4550

Corequisite(s):

ECE 5514:

Design of Systems on a Chip

Current state of the art in the system-level design of Systems on a Chip. The focus is in hardware, scheduling, and applications at the highest levels of design. Pre-requisite: Graduate Standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECE 4514 (UG) OR ECE 4514

Corequisite(s):

ECE 5520:

Secure Hardware Design

Design and implementation of secure hardware at multiple levels of abstractions, covering cryptographic hardware primitives, cryptographic hardware primitives, cryptographic modules using passive attacks, active attacks, and cryptanalytic techniques. Countermeasures against reverse engineering. The course uses case studies and literature surveys to reflect on the state-of-the-art in secure hardware implementation.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECE 4514 (UG) OR ECE 4514

Corequisite(s):

ECE 5534:

Electronic Design Automation

This course introduces graduate students to the various design automation artifacts, algorithms, and methodologies. It includes system level design languages, abstractions, models of computation, high level synthesis, modeling and model transformations, and simulation based validation. The course deals with state of the art design practices. It requires a solid back-ground in computer architecture, digital design, and proficiency in programming and modeling.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECE 4514 (UG) OR ECE 4514

Corequisite(s):

ECE 5545:

Advanced VLSI Design

Advanced concepts in CMOS-based digital system are studied. The topics include implementation of special purpose structures for complex digital systems, automation and verification of the design process, and design for testability (5545); and design techniques for low-power design, power dissipation estimation, and application of low-power techniques in the different levels of the design hierarchy (5546).

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECE 4540 (UG) OR ECE 4540

Corequisite(s):

ECE 5550G:

Advanced Real-Time Systems

Theory, algorithmic and protocol concepts, mechanisms, and implementations of real-time computer systems. Introduction to real-time systems, real-time scheduling, real-time synchronization, real-time operating systems kernels, and real-time programming languages. Design and analysis of real-time resource management algorithms (e.g., scheduling, synchronization), their implementations in production operating system kernels, experimental studies of those implementations, and real-time application development. Pre: Graduate

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ECE 5554:

Computer Vision

Techniques for automated analysis of images and videos. Image formation, feature detection, segmentation, multiple view geometry, recognition, and video processing. Pre: Graduate Standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s): null null

ECE 5560 (CS 5560):

Fundamentals of Info Security

Principles of information security and relevant mathematical concepts. Classical ciphers, relevant abstract algebra and number theory, symmetric-key ciphers, cipher modes of operation, and asymmetric-key ciphers. Cryptography and cryptosystems. Applications and standards relevant to network and computer security. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

ECE 5564:

Wearable and Ubiquitous Computing

Issues in the design and use of wearable and ubiquitous computing systems. Topics covered include current research issues in system-level low power design, input/output devices, location and context-awareness, and networking. Students are expected to design, implement, and evaluate a wearable computing device or application.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECE 4534 (UG) OR ECE 4550 (UG) OR ECE 4534 OR ECE 4550

Corequisite(s):

ECE 5565 (CS 5565):

Network Architecture and Protocols

5565: Principles and concepts of networking and protocols, with emphasis on data link, network, and transport protocols. Contemporary and emerging networks and protocols to illustrate concepts and to provide insight into practical networks including the Internet. Quantitative and qualitative comparisons of network architectures and protocols.

5566: Performance evaluation, design, and management of networks.

Use of queuing and other analytical methods, simulation, and experimental methods to evaluate and design networks and protocols.

Network management architectures and protocols. Graduate standing in EE, ECE, CS, or IT is required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): STAT 4714 (UG) OR STAT 4714

Corequisite(s):

ECE 5566 (CS 5560):

Network Architecture and Protocols

5565: Principles and concepts of networking and protocols, with emphasis on data link, network, and transport protocols. Contemporary and emerging networks and protocols to illustrate concepts and to provide insight into practical networks including the Internet. Quantitative and qualitative comparisons of network architectures and protocols.

5566: Performance evaluation, design, and management of networks.

Use of queuing and other analytical methods, simulation, and experimental methods to evaluate and design networks and protocols.

Network management architectures and protocols. Graduate standing in EE, ECE, CS or IT is required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECE 5565 (UG) OR ECE 5565

Corequisite(s):

ECE 5574G:

ADV Software Development CAE

Computer-aided engineering software that address the hierarchy of engineering analysis, design, and decision evaluation is developed with state-of-the-art computer tools. Linear graph theory is applied to the modeling of physical networks. Operator overloading, dynamic polymorphism, graphical user interfaces, dynamic link libraries, and multiple threaded programs are considered. Pre-requisite: Graduate

Standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ECE 5580:

Cryptographic Engineering

Implementation of cryptographic operations and protocols in contemporary computing platforms. Mapping of cryptographic operations, evaluation and optimization of performance and implementation cost, analysis of security against brute-force cryptanalysis and implementation-level attacks, security-testing procedures, and architectures to support a trusted computing base.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECE 5560 OR CS 5560

Corequisite(s):

ECE 5584 (CS 5584):

Network Security

Fundamentals of network security. Network security architecture, user and attacker perspective. Practical applications and security standards. Protocol design principles and their impact on computer and network security. Authentication systems. Email security. Firewalls and intrusion detection. Security for wireless systems.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECE 5560 OR CS 5560

Corequisite(s):

ECE 5585:

IT Security and Trust

5585: Fundamental Internet and computer security principles and applications; legal and privacy issues, risk analysis, attack techniques, intrusion detection concepts, basic computer forensics, and system and application security hardening techniques. 5586: Advanced security and trust concepts and implementation in wired and wireless computer networks and computer systems; malware defenses, impact of channel fragility, node mobility, cooperative functionality, and resource constraints on security and trust at the different layers of the Internet

protocol stack. Pre: Graduate standing for 5585.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ECE 5586:

IT Security and Trust

5585: Fundamental Internet and computer security principles and applications; legal and privacy issues, risk analysis, attack techniques, intrusion detection concepts, basic computer forensics, and system and application security hardening techniques. 5586: Advanced security and trust concepts and implementation in wired and wireless computer networks and computer systems; malware defenses, impact of channel fragility, node mobility, cooperative functionality, and resource constraints on security and trust at the different layers of the Internet protocol stack. Pre: Graduate standing for 5585.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECE 5585

Corequisite(s):

ECE 5590 (CS 5590):

System and Software Security

Secure software design, memory and file system security, operating system security for various platforms. Program classification, anomaly detection, malware detection and analysis. Technical challenges and problems in securing operating systems and software. Classic and modern algorithms, models, principles, and tools for system and application software security. Actual security examples.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): CS 5560 OR ECE 5560

Corequisite(s):

ECE 5604:

Computer-Aided Design and Analysis of Communication Systems

Simulation techniques for communication systems operating in random environments. Simulation models for stochastic signals and system components including coders, decoders, modulators, non-linear amplifiers, bit and carrier synchronizers, equalizers and receivers.

Techniques for modeling time-varying channels. Monte Carlo simulation, semi-analytic simulation and variance reduction techniques applied to the analysis, design and performance evaluation of communication systems. Programming experience required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): (ECE 4624 (UG), ECE 4634 (UG), STAT 4714 (UG)) OR (ECE 4624, ECE 4634, STAT 4714)

Corequisite(s): ECE 5605

ECE 5605 (BMES 5525):

Stochastic Signals and Systems

5605: Engineering applications of probability theory, random variables and random processes. Time and frequency response of linear systems to random inputs using both classical transform and modern state space techniques. 5606: Response of continuous and discrete time, linear and nonlinear systems to Gaussian and non-Gaussian random processes. Introduction to signal detection theory and optimal filtering (estimation) techniques.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): STAT 4714 (UG) OR STAT 4714

Corequisite(s):

ECE 5606:

Stochastic Signals and Systems

5605: Engineering applications of probability theory, random variables and random processes. Time and frequency response of linear systems to random inputs using both classical transform and modern state space techniques. 5606: Response of continuous and discrete time, linear and nonlinear systems to Gaussian and non-Gaussian random processes. Introduction to signal detection theory and optimal filtering (estimation) techniques.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECE 5605 (UG) OR ECE 5605

Corequisite(s):

ECE 5620:

Advanced DSP and Filter Design

Advanced analysis, design, and realization of digital filters. Efficient

Discrete Fourier Transform algorithm implementations, finite wordlength arithmetic, fixed point implementation, limit cycles, noise shaping, decimation and interpolation, multi-rate digital filter design, Hilbert transformers, analytic signal generation, basic adaptive filtering.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): (ECE 4624 (UG), STAT 4714 (UG)) OR (ECE 4624, STAT 4714)

Corequisite(s):

ECE 5634:

Information Theory

Transmission of information over noisy channels. Measures of information and transmission channel capacity. Use of codes to improve the reliability of such transmission. Mathematical theory of information. Transmission at rates above channel capacity. Includes linear codes, error detecting and correcting codes, Hamming codes.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): (STAT 4714 (UG), ECE 4634 (UG), ECE 5605 (UG)) OR (STAT 4714, ECE 4634, ECE 5604)

Corequisite(s):

ECE 5635:

Radar Systems Analysis and Design

5635: This graduate-level course is the first in a two-part sequence in radar analysis and design. It covers the theory and practice of radar systems used for detection, tracking and location of targets. Topics include measurement of range and velocity, pulse compression, design of radar transmitter, receivers and antennas. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECE 5605

Corequisite(s):

ECE 5636:

Radar Systems Analysis and Design

5636: This graduate-level course is the second in a two-part sequence in radar analysis and design. It covers signal processing techniques used in pulsed radar systems. Topics include signal modeling, matched filter, frequency-modulated pulse compression waveforms, pulse Doppler

processing, the Neyman-Pearson detection theory, constant false-alarm rate detection, beamforming and space-time adaptive processing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECE 5635

Corequisite(s):

ECE 5644:

Game Theory for Communication Networks

Analysis and optimization of large-scale engineering systems and communication networks using game theory. Introduction to the basics of game theory and its two branches- noncooperative and cooperative games-with application to the design of emerging communication systems and networks. A comprehensive treatment of the basics of game theory and learning with communication networking examples drawn from various areas such as cellular networks, mobile ad hoc networks, and related fields. Pre: Graduate Standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

ECE 5654:

Digital Communications II: Advanced Theory and Analysis

Fundamentals of the theory, design, and analysis of modern digital communication systems. Representation of signal in digital form. Design and analysis of digital modulation formats and receivers using signal space techniques. Combining error correction techniques with digital modulation. Viterbi algorithm for maximum likelihood sequence estimation. Equalization and adaptive equalization. Fading channels and diversity techniques.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): (ECE 4634 (UG), ECE 5605 (UG)) OR (ECE 4634, ECE 5605)

Corequisite(s):

ECE 5660:

Spread Spectrum Communications

Major topics include: direct sequence and frequency hopping methods, synchronization, resistance to jamming, low probability of detection,

spreading codes and their generation, system performance, RAKE receivers, Code Division Multiple Access, cellular CDMA applications, wireless LAN applications, as well as commercial and military applications.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): (ECE 4634 (UG), ECE 5605 (UG)) OR (ECE 4634, ECE 5605)

Corequisite(s):

ECE 5664:

Cellular Communication Systems

Fundamental theory, design tradeoffs and practical issues of high capacity wireless communications systems. Trunking, RF propagation, frequency reuse, and legacy and emerging radio communications systems, including Long Term Evolution (LTE) cellular networks.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECE 5605

Corequisite(s):

ECE 5665:

Telecommunications

5665: Basic concepts in electrical engineering. Waveforms, spectra bandwidth. Fourier series and transform. Decibels, SNR, BER. Analog and digital transmission and modulations. Wire and radio links, link budgets, SNR and BER. Pre: Graduate standing. 5666: Analog modulations, AM, FM. Digital Modulations, ASK, FSK, PSK, QAM. RRC filtering, digital transmissions. Multiplexing, multiple access. Error control, FEC, ARQ. Local area networks. Optical communication systems. Satellite communications, GPS.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ECE 5666:

Telecommunications

5665: Basic concepts in electrical engineering. Waveforms, spectra bandwidth. Fourier series and transform. Decibels, SNR, BER. Analog and digital transmissions and modulations. Wire and radio links, link

budgets, SNR and BER. Pre: Graduate standing 5666: Analog modulations, AM, FM. Digital Modulations, FSK, PSK, QAM. RRC filtering, digital transmission. Multiplexing, multiple access. Error control, FEC, ARQ. Local area networks. Optical communication systems. Satellite communications, GPS.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECE 5665

Corequisite(s):

ECE 5674:

Software Radios: Modern Radio Engineering

An introduction to software radios, devices that can be programmed to work with a variety of different radios. The course will cover the following topics: software radio architectures, existing software radio efforts, a review of basic principles, an analysis of receiver operation.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): (ECE 4624 (UG), ECE 4634 (UG)) OR (ECE 4624, ECE 4634)

Corequisite(s):

ECE 5684:

Error Control Coding

Use of error control codes to improve the reliability of digital communication and storage systems in the presence of noise. Algebraic structure of codes over finite fields. Error detecting and correcting codes. Block codes and convolutional codes, including Reed Solomon codes, LDPC codes, and turbo codes. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ECE 5704 (ME 5704):

Robotics and Automation

Automation, mechatronics, robot technology, kinematics, dynamics, trajectory planning, and control of two-dimensional and spatial robots; robot programming; design and simulation of robotic devices.

Laboratories associated with robot forward/inverse kinematics, task planning, velocity kinematics, force rendering, control, haptics, mobile

robotics, mapping/localization, computer vision and path planning. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 2

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

ECE 5714:

Robust Estimation and Filtering

An introduction to the analysis and design of maximum likelihood and robust estimators and filters. Maximum likelihood estimation theory: consistency, asymptotic efficiency, sufficiency. Robust estimation theory: qualitative robustness, breakdown point, influence function, change-of-variance function. Robust estimators: M-estimators, generalized M-estimators, high-breakdown estimators. Robust estimation of ARIMA models; Robust Kalman filter. Long memory processes: Hurst parameter estimation; parameter estimation of fractional ARIMA models. Applications to image and speech processing, communications, radar systems, and electric power systems.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECE 5605

Corequisite(s):

ECE 5734 (AOE 5734) (ME 5584):

Convex Optimization

Recognizing and solving convex optimization problems. Convex sets, functions, and optimization problems. Least-squares, linear, and quadratic optimization. Geometric and semidefinite programming. Vector optimization. Duality theory. Convex relaxations. Approximation, fitting, and statistical estimation. Geometric problems. Control and trajectory planning. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ECE 5744 (AOE 5744) (ME 5544):

Linear Systems Theory

Advanced introduction to the theory of time-varying and time-invariant linear systems represented by state equations; solutions of linear

systems, uniform stability and other stability criteria, uniform observability and controllability, state feedback and observers.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECE 4405 OR ECE 4405 (UG) OR ECE 4624 (UG) OR ECE 4624 OR ECE 4634 (UG) OR ECE 4634 OR ME 4504 (UG) OR ME 4504 OR AOE 4004 (UG) OR AOE 4004

Corequisite(s):

ECE 5754 (AOE 5754) (ME 5554):

Applied Linear Systems

Develop an applied understanding of state-space representations for linear time invariant multi-input multi-output dynamic systems in both time domain and frequency domain. Introduction to modern state-space control methods; state feedback and output feedback. Realistic design problems with numerical simulations of practical implementations.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECE 4405 OR ECE 4624 OR ECE 4634 OR ME 4504 OR AOE 4004 OR ECE 4405 (UG) OR ECE 4624 (UG) OR ECE 4634 (UG) OR ME 4504 (UG) OR AOE 4004 (UG)

Corequisite(s):

ECE 5764 (AOE 5764) (ME 5564):

Applied Linear Control

Analysis and design of sampled-data systems, extraction of discrete-time dynamic models from experimental data, and implementation of dynamic compensators on digital processors. In-depth design experience with LQR optimal control and an introduction to Kalman filtering. Realistic design problems with numerical simulations of practical implementations.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECE 5744 OR ECE 5754 OR ME 5554 OR ME 5544 OR AOE 5744 OR AOE 5754

Corequisite(s):

ECE 5774 (AOE 5774) (ME 5574):

Nonlinear Systems Theory

Introduction to the theory of systems of coupled, nonlinear, time-varying ordinary differential equations: existence and uniqueness of solutions;

continuous dependence on parameters; stability of equilibria and stability analysis techniques; input-to-state stability; input-output stability; nonlinear design techniques including input-state and input-output feedback linearization, backstepping, and sliding mode control.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECE 4405 (UG) OR ECE 4405 OR ECE 4624 (UG) OR ECE 4624 OR ECE 4634 (UG) OR ECE 4634 OR ME 4504 (UG) OR ME 4504 OR AOE 4004 (UG) OR AOE 4004

Corequisite(s):

ECE 5805:

Graduate Design Project and Report

Industry-like two semester, team-based design experience. Design and implement solutions to meet multiple realistic constraints; design to incorporate appropriate engineering standards. A specific, complex engineering design problem taken from problem definition to product realization and testing. Written and oral communication, professional development, project management, and working within a team. 5805: Determine and formulate an engineering problem with multiple realistic constraints. Generate and select design alternatives. Apply design and analysis methods to develop, evaluate, and communicate a detailed project design. 5806: Implement and refine the project design from ECE 5805. Test, analyze, document, and deliver the resulting project outcomes. A final oral and written examination that satisfies the Master of Engineering (MEng) program requirements. Pre: Graduate standing in Electrical Engineering and Computer Engineering Master of Engineering degree students only for 5805; 5805 (B) for 5806.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ECE 5806:

Graduate Design Project and Report

Industry-like two semester, team-based design experience. Design and implement solutions to meet multiple realistic constraints; design to incorporate appropriate engineering standards. A specific, complex engineering design problem taken from problem definition to product realization and testing. Written and oral communication, professional development, project management, and working within a team. 5805: Determine and formulate an engineering problem with multiple realistic constraints. Generate and select design alternatives. Apply design and

analysis methods to develop, evaluate, and communicate a detailed project design. 5806: Implement and refine the project design from ECE 5805. Test, analyze, document, and deliver the resulting project outcomes. A final oral and written examination that satisfies the Master of Engineering (MEng) program requirements. Pre: Graduate standing in Electrical Engineering and Computer Engineering Master of Engineering degree students only for 5805; 5805 (B) for 5806.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECE 5805

Corequisite(s):

ECE 5894:

Final Examination

NONE

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ECE 5904:

Project and Report

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research, Online Research

Instruction Type(s): Research, Online Research

Prerequisite(s):

Corequisite(s):

ECE 5914:

Autonomous Systems Seminar

Weekly technical presentations from local and visiting scholars on current topics related to the theory, design and development, and application of autonomous vehicle systems. Pre-requisite: Graduate Standing required

Credit Hour(s): 1

Lecture Hour(s): 1

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ECE 5944:

Seminar

To acquaint graduate students with recent and current research results and trends and to introduce researchers to students performing important work in Electrical and Computer Engineering.

Credit Hour(s): 1

Lecture Hour(s): 1

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ECE 5964:

Field Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ECE 5974:

Independent Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Independent Study, VI

Instruction Type(s): Independent Study, VI

Prerequisite(s):

Corequisite(s):

ECE 5984:

Special Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ECE 5994:

Research and Thesis

NONE

Credit Hour(s): 1 TO 19

317 Lecture Hour(s):

Instruction Type(s): Research, Online Research

Instruction Type(s): Research, Online Research

Prerequisite(s):

Corequisite(s):

ECE 6104:

Advanced Topics in Electromagnetics

Advanced topics of current interest in Electromagnetic Engineering.

Topics are selected from current technical literature. May be repeated for credit.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECE 5105

Corequisite(s):

ECE 6114:

Advanced Analytical Electromagnetics

This course comprises PhD-level material covering exact and asymptotic analytical techniques for the solution of advanced electromagnetic problems involving wave propagation and scattering by finite and extended media inhomogeneities.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECE 5106 (UG) OR ECE 5106

Corequisite(s):

ECE 6115:

Antenna Theory and Design I,II

6115: Antenna systems and arrays: antennas in systems, antenna synthesis array fundamentals, array excitation and mutual impedance, waveguide slot arrays, microstrip antennas, microstrip elements, microstrip planar and conformal arrays, numerical methods for antenna analysis, Method of Moments and FDTD, antenna measurements, phased arrays. 6116: Reflectors and aperture antennas: aperture theory, analytical and computer-based designs, reflector antenna fundamentals, numerical methods for reflector analysis, general formulation of GO, PO, GTD, PTD and UTD methods, Gaussian beams, reflector optic configurations, prime-symmetric, Gregorian, Cassegrain and prime-offset reflector systems, analysis of strut scattering, aperture blockage, spillover, G/T analysis, measuring and commissioning reflector systems, reflector feed array, focal plane arrays, defocused arrays.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECE 5105

Corequisite(s): null null

ECE 6116:

Antenna Theory and Design I,II

6115: Antenna systems and arrays: antennas in systems, antenna synthesis, array fundamentals, array excitation and mutual impedance, waveguide slot arrays, microstrip antennas, microstrip elements, microstrip planar and conformal arrays, numerical methods for antenna analysis, Method of Moments and FDTD, antenna measurements, phased arrays. 6116: Reflectors and aperture antennas: aperture theory, analytical and computer-based designs, reflector antenna fundamentals, numerical methods for reflector analysis, general formulation of GO, PO, GTD, PTD and UTD methods, Gaussian beams, reflector optic configurations, prime-symmetric, Gregorian, Cassegrain and prime-offset reflector systems, analysis of strut scattering, aperture blockage, spillover, G/T analysis, measuring and commissioning reflector systems, reflector feed array, focal plane arrays, defocused arrays.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECE 5105

Corequisite(s): null null

ECE 6124:

Advanced Numerical Electromagnetics

A thorough coverage of numerical methods for electromagnetics, including topics on the foundations of function theory, Greens functions, mode-matching, and numerical expansion techniques in both the time and frequency domains. Emphasis will be placed on the method of moments and the finite element method, with development of the theoretical foundations of these methods. Alternate year course.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECE 5106 (UG) OR ECE 5106

Corequisite(s):

ECE 6154:

Photonic Devices and Systems

Electromagnetic analysis of guided-wave optical devices and systems, including transmission properties of optical fibers, photonic crystal

propagation in fibers; Erbium-doped and Raman fiber amplifiers; semiconductor light sources and photodetectors; wavelength-division multiplexed systems.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECE 5105

Corequisite(s):

ECE 6174 (AOE 6174):

Computational Plasma Dynamics

Computational techniques for investigating processes in plasmas over a broad range of spatial and temporal scales. Investigation of physical processes including electrodynamics, waves and turbulence, space propulsion, spacecraft environmental effects and various laboratory applications. Computational techniques including full Particle-in-Cell (PIC), hybrid (fluid-electron, PIC ion), magnetohydrodynamics MHD and two-fluid methods.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECE 5174 OR AOE 5174

Corequisite(s):

ECE 6204:

Advanced Topics in Electronics

Advanced topics of current interest in electronics engineering, with particular emphasis on microelectronics. Topics are selected from current technical literature to stress and reflect important potential areas in the electronic field. These topics include multichip modules, electronic packaging, microwave packaging, modeling simulation and evaluation of high speed devices, wideband characterization of electronic materials and multilayer structures, time and frequency domain measurement techniques.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ECE 6214:

Optoelectronic Devices

Principles of light generation and detection, operation, and design of state-of-the-art optoelectronic and photonic devices. Advanced treatment

of the operating principles of semiconductor optoelectronic devices with direct comparison to experimental data reported in the literature.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECE 5200

Corequisite(s):

ECE 6304:

Advanced Topics in Power

Advanced topics of current interest in Electric Power Engineering. Topics are selected from current technical literature. Certain topics may be repeated.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ECE 6314:

Advanced Instrumentation in Power Systems

Role of advanced instrumentation in monitoring, control and protection applications in power systems. Effects and limitations of instrument transformers, signal conditioning circuits, analog to digital (A/D) converters and Digital Signal Processing (DSP) chips, time synchronization and sampling, output circuits and devices, and communication channels. Fast Fourier Transform (FFT), protection algorithms, phasor and frequency measurements.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECE 5314

Corequisite(s):

ECE 6334:

Computational Methods in Power Engineering

This course is designed to introduce various linear and nonlinear program based optimization algorithms that are specially suited for the design, analysis and operation of electric power systems, power processing devices, machines, and transformers.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECE 5324 (UG) OR ECE 5324

Corequisite(s):

ECE 6354:

Power System Dynamics and Control

Dynamic modeling, stability analysis, and control of multi-machine power systems. Single-machine dynamic modeling, multi-machine dynamic modeling, network differential-algebraic equations and solution methods, small-signal stability analysis, and design of power system stabilizers.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECE 5314

Corequisite(s):

ECE 6424:

PGMs and Structured Prediction

Advanced concepts in machine learning. Probabilistic graphical models and structured output prediction. Directed models (Bayes Nets), undirected models (Markov/Conditional Random Fields), exact inference (junction tree), approximate inference (belief propagation, dual decomposition), parameter learning (MLE, MAP, EM, max-margin), structure learning.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECE 5424G OR CS 5824

Corequisite(s):

ECE 6504:

Advanced Topics in Computer Engineering

Advanced topics of current interest in computer engineering which are taken from current research topics and/or technical publications.

Prerequisites at 5000 level dependent on specific topics.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ECE 6524 (CS 6524):

Deep Learning

Advanced concepts in Machine Learning and Deep Learning. Models (multi-layer perceptrons, convolutional neural networks, memory

networks), learning algorithms (backpropagation, stochastic sub-gradient descent, dropout), connections to structured predictions (Boltzmann machines, unrolled belief propagation), and applications to perception and Artificial Intelligence (AI) problems (image classification, detection, and segmentation; image captioning; visual question answering; automatic game playing).

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECE 5424G OR CS 5824

Corequisite(s):

ECE 6554:

Advanced Computer Vision

Current and state-of-the-art trends in computer vision, particularly in object recognition and scene understanding. Application of approaches in computer vision to various automatic perception problems. Strengths and weaknesses of computer vision techniques. Open questions and future research directions. Pre: 5554.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECE 5554

Corequisite(s):

ECE 6564 (CS 5584):

Multimedia Networking

This course examines and explores recent advances in multimedia networking technologies. Major topics include multimedia compression and standards, quality of service (QoS) support mechanisms and protocols, performance analysis, network calculus, IP multicasting, Internet multimedia applications, and multimedia transport over wireless networks.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECE 5565 (UG) OR ECE 5565

Corequisite(s):

ECE 6570:

Advanced Foundations of Networking

This course covers theoretical foundations that are necessary for advanced study of networking. It focuses on algorithm design and

networking problems. Major topics include complexity analysis with applications to networking problems, design and proof of approximation algorithms, design of meta-heuristic algorithms, formulation techniques for network optimization, linear and non-linear optimization techniques with applications to networking, design of distributed algorithms with proof of convergence for networks systems.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECE 5565 (UG) OR CS 5565 (UG) OR ECE 5565 OR CS 5565

Corequisite(s):

ECE 6604:

Advanced Topics in Communications

Advanced topics of current interest in communications, which are taken from publications and industrial information.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECE 5654 OR ECE 5655

Corequisite(s):

ECE 6634:

Multi-Channel Communications

In-depth study of modern multi-channel communications techniques, primarily multi-antenna systems (known as multiple input multiple output or MIMO) and Orthogonal Frequency Division Multiplexing (OFDM). Specifically the course examines multi-antenna techniques such as transmit and receive diversity, beamforming (including eigen-beamforming), and spatial multiplexing. Within the area of OFDM we examine modulation/demodulation, carrier bit loading, mitigating multipath, frequency-domain equalization, peak to average power reduction, and frequency offset mitigation. As time permits we will also investigate a third multi-channel technique known as multi-user scheduling or packet access networks.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECE 5605, ECE 5654

Corequisite(s):

ECE 6744 (AOE 6744) (ME 6544):

Linear Control Theory

Advanced introduction to the theory of optimal control of time-varying and time-invariant linear systems; Solutions to the linear-quadratic regulator, optimal filtering, and linear-quadratic-gaussian problems; Robustness analysis and techniques to enhance robustness of controllers.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECE 5744 OR ECE 5754 OR ME 5544 OR ME 5554 OR AOE 5744 OR AOE 5754

Corequisite(s):

ECE 6774 (ISE 6574) (AOE 6774) (ME 6574):

Adaptive Control Systems

Introduction to the theory and methodology used to design adaptive controllers for uncertain systems, addressing issue such as input constraints, disturbance rejection, partial measurements, and robustness.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): (ECE 5774, ECE 5744) OR (ME 5544, ME 5574) OR (AOE 5774, AOE 5744)

Corequisite(s):

ECE 6984:

Special Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ECE 7994:

Research and Dissertation

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research, Online Research

Instruction Type(s): Research, Online Research

Prerequisite(s):

Corequisite(s):

COMPUTER SCIENCE & APPLICATIONS

Calvin Ribbens, Head

Emeriti Faculty: James Arthur; Roger Ehrich; Hillyard Hartson; Barbara Ryder;

Professors: Osman Balci; Douglas Bowman; Ali Butt; Kirk Cameron; Ing Ray Chen; Stephen Edwards; Wu-Chun Feng; Edward Fox; Lenwood Heath; Dennis Kafura; Benjamin Knapp; Wenjing Lou; Chang Tien Lu; T Murali; Dimitrios Nikolopoulos; Christopher North; Alexey Onufriev; Narendran Ramakrishnan; Calvin Ribbens; Adrian Sandu; Clifford Shaffer; Deborah Tatar; Layne Watson; Danfeng Yao;

Associate Professors: Godmar Back; Young Cao; Jin-Hee Cho; Hoda Eldardiry; Denis Gracanin; Bo Ji; Aisling Kelliher; Donald McCrickard; Chandan Reddy; Eli Tilevich; Liqing Zhang;

Assistant Professors: Taejoong Chung; Muhammad Ali Gulzar; Shaddi Hasan; Matthew Hicks; Thang Hoang; Lifu Huang; Xun Jian; Anuj Karpatne; Sang Won Lee; Kurt Luther; Na Meng; Sharath Raghvendra; Eugenia Rho; Francisco Servant Cortes; Jamie Sikora; Bimal Viswanath;

Research Faculty: David McPherson;

Affiliated Faculty: Nicholas Polys;

Frank J. Maher Professor: Douglas Bowman;

Associate Professor of Practice: Steven Harrison;

Research Scientists: Andrea Kavanaugh;

Thomas L. Phillips Professor of Engineering: Narendran Ramakrishnan;

Elizabeth and James E. Turner, Jr. '56 Faculty Fellow; CACI Faculty Fellow: Danfeng Yao;

W.C. English Professor: Wenjing Lou;

Assistant Professor of Practice: Margaret Ellis; Gregory Kulczycki;

Collegiate Assistant Professors: Andria Esakia;

John W. Hancock, Jr Professor of Engineering: Dimitrios Nikolopoulos;

Collegiate Associate Professors: Sara Hooshangi;

General Contact: gradprog@cs.vt.edu

Graduate Site: <http://cs.vt.edu/Graduate.html>

The graduate program at the Department of Computer Science at Virginia Tech is poised to become one of the top programs in the country. #40 in the US News and World Report 2018 rankings for graduate CS programs, additional accolades include being ranked in the top 20 CS departments in US Colleges of Engineering by number of Ph.D. degrees awarded.

SPECIAL FACILITIES

Laboratories in the Department of Computer Science in Blacksburg are distributed across three buildings: McBryde Hall, Torgersen Hall, and the KnowledgeWorks II (KWII) building in the Corporate Research Center (CRC). The Department of Computer Science at NCR is housed at the Virginia Tech NCR building in Falls Church and VTRC building in Arlington.

Bioinformatics Lab

The bioinformatics group on campus hosts and maintains several dedicated resources. The Espresso database server provides over 2TB of storage and is accessible to any of our research workstations & servers via our internal Gig-E network. Baobab is a 6 node Gig-E research cluster with 8 processor cores & 32GB of memory per node.

Mnemosyne and Mnemosyne2 are high memory dedicated servers for intense memory usage calculations and is used by graduate and faculty researchers for large dataset manipulation. Kuprin is a NVidia cuda GPU processor machine using triple nVidia GTX680 cards.

Center for Human-Computer Interaction (CHCI)

Many Computer Science faculty and students are affiliated with the Center for Human-Computer Interaction (CHCI; hci.vt.edu), an interdisciplinary community of scholars focusing on human aspects of computing—understanding and designing for human use of interactive systems. Current CHCI research is focused on 3D Experiences (virtual reality, augmented reality, and visualization) and Social Informatics. Faculty and students affiliated with CHCI have access to a wide variety of resources for research, including the Cube (large motion-capture and spatial audio theater in the Moss Arts Center), the Visionarium (visualization facility including a four-wall CAVE system), a 3D Experiences Studio in the Moss Arts Center, additional design studios in the Media Building and Moss Arts Center, usability laboratories in McBryde Hall, and project rooms in VT KnowledgeWorks II. The CHCI maintains an inventory of shared mobile equipment (cameras, tablets, input devices, eye trackers, etc.) that can be reserved and checked out by affiliated faculty and students.

Discovery Analytics Center (DAC)

The Discovery Analytics Center (DAC; <http://dac.cs.vt.edu>) is an interdisciplinary research center at Virginia Tech with labs and facilities across the commonwealth in Blacksburg, Falls Church, and Arlington. The center's focus is on data analytics and machine learning to tackle knowledge discovery problems in important areas of national interest, such as intelligence analysis, sustainability, and public health. DAC currently is comprised of 16 academic faculty members, 6 research and professional faculty and over 90 Ph.D. students from computer science, statistics, electrical and computer engineering, and mathematics. DAC administers the graduate certificate in data analytics and the graduate certificate in urban computing. Our curriculum emphasizes not just the algorithmic aspects of converting data to knowledge but also the importance of human-in-the-loop analytics to arrive at insights. DAC researchers have access to high-performance computing facilities for big data analytics (including clusters and GPU machines), large-screen visualization displays and, most importantly, a variety of massive datasets collected in real-world contexts (e.g., social media, transportation, publishing, and real estate).

General Departmental Resources

The department maintains a pool of highly available virtualized servers to support email, web, and file services. Computer Science resources available to graduate students include: an @cs.vt.edu email address, a personal web site, and central file storage. Additional resources are available for research and instruction. Resources available for research include: virtualized servers, web site space, and backups. Resources available for instruction include: IaaS (infrastructure as a service), web site space, and a remote login cluster. Various research groups also offer special-purpose facilities to their members.

Laboratory for Advanced Scientific Computing and Applications (LASCA)

The goal of the Laboratory for Advanced Scientific Computing and Applications (LASCA) is to provide expertise and leadership in high-end scientific computing research and education at Virginia Tech. Located in Torgersen Hall, the laboratory is a visible and strategic center of activity in applied high-performance computing on campus. LASCA participants do basic research in high-performance parallel computation and assist scientists and engineers in applying high-end computing resources to their problems. By bringing together experts in scientific computing and its applications, LASCA helps build the kind of multidisciplinary teams needed to address today's most challenging computational science problems.

stack@cs Center for Computing Systems

The stack@cs Center for Computer Systems (<http://stack.cs.vt.edu>) tackles challenging problems that transcend any single component of the application software and architecture stack and require interdisciplinary solutions. This requires the collaborative expertise of computer scientists and engineers, domain scientists, and educators spanning multiple departments across the College of Engineering and the College of Science as well as other research organizations such as ICAT and ICTAS. stack@cs Center faculty have a rich history of interdisciplinary collaborations that contribute to the evolving education and research missions of the college and university.

DEGREES OFFERED

MS Degree

Offered In (Blacksburg, National Capital Region)

TOEFL

Paper: (577.0)

iBT: (90.0)

The Master of Science degree provides a solid foundation in computer science while still offering flexibility to meet the needs and interests of individual students. The MS Thesis option requires 30 credits of course work of which typically 21 credits must derive from graded courses. Students in good standing typically complete this option in two years.

Students taking a terminal MS degree are expected to complete the thesis. The MS coursework-only option is intended for PhD students who seek a "MS along-the-way". Students who wish a coursework-only degree at the Master's level should enroll in the MENG degree program. The MS thesis option requires 30 credits of course work of which typically 21-24 credits derive from courses and 6-9 credits from research work. At least one advanced graduate course must be included on the plan of study. Students must satisfy the breadth requirement by taking CS courses at the 5000 and 6000 levels that span four (4) different areas, adhere to an appropriate credit distribution, complete the graduate seminar twice, comply with the ethics and diversity requirements by completing either CS5014 or CS5024, and complete an oral and written final exam (also known as a Master's Thesis). Students in good standing typically complete the degree option in two years. The Computer Science department offers the accelerated BS/MS degree programs in accordance to graduate school policies and the following criteria. Students must be accepted into the program prior to the beginning of the semester in which they would enroll in courses to be used on the accelerated program. Students qualifying for the program must be in the last 12 months of their undergraduate degree and must have a minimum GPA of 3.5. Once completion of the undergraduate degree has been verified, students accepted into this accelerated program will be classified as regular graduate students. A maximum of 12 credits of graded coursework may be used in the program. No more than 6 of the double-counted credits may be at the 4000 level; all others must be offered for graduate credit. A grade of B or higher must be earned in each course to be double counted. Courses must not be taken pass-fail if a graded option is available.

Degree Concentrations:

Bioinformatics Option

Students receiving the option will have that fact noted on their transcript upon successful graduation. To receive the option, students will take a minimum of seven (7) additional credits beyond those necessary for the degree without the option. Other requirements include: Students receiving the Bioinformatics option must take PPWS 5314 Biological Paradigms for Bioinformatics (3 credits), BCHM 5024 Computational Biochemistry for Bioinformatics (3 credits), and GBCB 5004 Seminar (1 credit). PPWS 5314, BCHM 5024, and GBCB 5004 may not be used both to complete the option and to satisfy CSA degree course requirements. Students who already have background equivalent to PPWS 5314 and/or BCHM 5024 may be permitted to substitute more advanced courses to satisfy this requirement. Students receiving the Bioinformatics option must take ONE of STAT 5615 (Statistics in Research), STAT 5616 (Statistics in Research), MATH 5515 (Modeling and Simulation of Biological Systems), or MATH 5516 (Modeling and Simulation of Biological Systems). These courses may also be used to fulfill CSA coursework requirements. Students must complete the final exam requirement for their respective CSA degree using a topic suitable for the Bioinformatics option. MS coursework-only students must take GBCB 5874 Problem Solving in Genetics, Bioinformatics, and Computational Biology, and use the final report from this course to satisfy their final exam requirement.

Graduate Certificate in Human-Computer Interaction

The Graduate Certificate in Human-Computer Interaction is administered by the Center for Human Computer Interaction and can be obtained in conjunction with either the M.S. or Ph.D. degree. Master's degree students complete 9 hours and doctoral students 15 hours of coursework for the certificate, where at least two of the courses taken must be outside the student's degree program requirements and outside the department. Students interested in the Graduate Certificate in Human-Computer Interaction should confer with the director of the Center for Human Computer Interaction prior to submitting a program of study to the Graduate School. to submitting a program of study to the Graduate School. (<http://www.hci.vt.edu>)

Human Centered Design Graduate Certificate

The act of creating something new shows up in many human endeavors. Human Centered Design (HCD) is an approach to design charged with understanding the needs, wants, and limitations of end-users which can be an important perspective for graduate research. The Human Centered Design graduate certificate combines technical expertise with critical inquiry to develop reflective practitioners equipped to meet vital human needs; it is based in the Interdisciplinary Graduate Education Program of the Graduate School. The HCD/IGEP degree is built around competencies in four core areas: (1) Interdisciplinary Research, (2) Design Studies, (3) Understanding People, and (4) Design Realization. Students learn the core ideas of HCD, explore how it applies in their own professional domains, and discover how their own research connects with projects in other disciplines.

Graduate Certificate In Data Analytics

The Graduate Certificate in Data Analytics prepares students for technical careers in big data analytics and data science. Students learn to develop new analytical methods and tools by integrating the computational, statistical, and engineering techniques that form the heart of big data analytics. The certificate is open to degree- and non-degree seeking students. Students complete four courses from an interdisciplinary selection, spanning Computer Science, Statistics, and Electrical and Computer Engineering. Details and checksheet are available at <http://dac.cs.vt.edu/>.

Graduate Certificate in Urban Computing

The Graduate Certificate in Urban Computing trains students in the latest methods in analyzing massive datasets to study key issues concerning urban populations. Students learn to apply methods in data analytics, computational modeling, and visualization. The certificate is open to degree- and non-degree seeking students. Students complete 12 hours of coursework for the certificate from an interdisciplinary selection, spanning Civil and Environmental Engineering, Computer Science, Electrical and Computer Engineering, Mathematics, Population Health Sciences, Sociology, Statistics, and Urban Affairs and Planning. Details and checksheet are available at [https://dac.cs.vt.edu/academics/urban-](https://dac.cs.vt.edu/academics/urban-computing/)

computing/.

PhD Degree

Offered In (Blacksburg, National Capital Region)

TOEFL

Paper: (577.0)

iBT: (90.0)

A student pursuing the Ph.D. degree is expected to exhibit a comprehensive knowledge of a broad cross section of the computer science discipline and to contribute significant new knowledge to the discipline through the research contribution contained in the doctoral dissertation. A PhD student must complete a minimum of 90 credits of graduate study, of which at least 27 must derive from courses. The PhD program is intended to be completed in about five years from entering the graduate program with a BS degree in Computer Science or a related field, or about four years if the student already has an MS degree in Computer Science or a related field. To encourage Ph.D. graduates to exhibit sufficient breadth of computer science and its application areas, Ph.D. students must take CS courses spanning four (4) computer science different areas and one to three cognate (i.e., outside CS) courses. At least two advanced CS graduate courses must be included on the plan of study.

Degree Concentrations:

Bioinformatics Option

Students receiving the option will have that fact noted on their transcript upon successful graduation. To receive the option, students will take a minimum of seven (7) additional credits beyond those necessary for the degree without the option. Other requirements include: Students receiving the Bioinformatics option must take PPWS 5314 Biological Paradigms for Bioinformatics (3 credits), BCHM 5024 Computational Biochemistry for Bioinformatics (3 credits), and GBCB 5004 Seminar (1 credit). PPWS 5314, BCHM 5024, and GBCB 5004 may not be used both to complete the option and to satisfy CSA degree course requirements. Students who already have background equivalent to PPWS 5314 and/or BCHM 5024 may be permitted to substitute more advanced courses to satisfy this requirement. Students receiving the Bioinformatics option must take ONE of STAT 5615 (Statistics in Research), STAT 5616 (Statistics in Research), MATH 5515 (Modeling and Simulation of Biological Systems), or MATH 5516 (Modeling and Simulation of Biological Systems). These courses may also be used to fulfill CSA coursework requirements. Students must complete the final exam requirement for their respective CSA degree using a topic suitable for the Bioinformatics option. MS coursework-only students must take GBCB 5874 Problem Solving in Genetics, Bioinformatics, and Computational Biology, and use the final report from this course to satisfy their final exam requirement.

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obtained in conjunction with either the M.S. or Ph.D. degree. Master's degree students complete 9 hours and doctoral students 15 hours of coursework for the certificate, where at least two of the courses taken must be outside the student's degree program requirements and outside the department. Students interested in the Graduate Certificate in Human-Computer Interaction should confer with the director of the Center for Human Computer Interaction prior to submitting a program of study to the Graduate School. to submitting a program of study to the Graduate School. (<http://www.hci.vt.edu>)

Human centered Design Graduate Certificate

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Graduate Certificate in Data Analytics

The Graduate Certificate in Data Analytics prepares students for technical careers in big data analytics and data science. Students learn to develop new analytical methods and tools by integrating the computational, statistical, and engineering techniques that form the heart of big data analytics. The certificate is open to degree- and non-degree seeking students. Students complete four courses from an interdisciplinary selection, spanning Computer Science, Statistics, and Electrical and Computer Engineering. Details and checksheet are available at <http://dac.cs.vt.edu/>.

Graduate Certificate in Urban Computing

The Graduate Certificate in Urban Computing trains students in the latest methods in analyzing massive datasets to study key issues concerning urban populations. Students learn to apply methods in data analytics, computational modeling, and visualization. The certificate is open to degree- and non-degree seeking students. Students complete 12 hours of coursework for the certificate from an interdisciplinary selection, spanning Civil and Environmental Engineering, Computer Science, Electrical and Computer Engineering, Mathematics, Population Health Sciences, Sociology, Statistics, and Urban Affairs and Planning. Details and checksheet are available at <https://dac.cs.vt.edu/academics/urban-computing/>.

MEng Degree

Offered In (Blacksburg, National Capital Region)

TOEFL

Paper: (577.0)

iBT: (90.0)

The Master of Engineering (MEng) degree provides advanced training in Computer Science at the graduate level, with an emphasis on practical coursework that prepares students for a wide range of employment in the computing field. The MEng degree program is open to students with less formal Computer Science background, since it includes the coursework needed to prepare such students for more advanced Computer Science courses. The MEng degree has a single coursework-only option that requires 30 credits derived from graded courses. This includes a required course related to ethics in computing and a project-oriented Capstone course. Students are required to complete a cluster of three courses to ensure depth in some practical aspect of computing. Full-time students in good standing can typically complete the program in three academic terms. The Computer Science Department offers the accelerated BS/MEng degree. This program allows students to count up to 12 credits of the graded coursework toward both the BS and the MEng degree.

GRADUATE COURSES (CS)

CS 5014:

Research Methods in Computer Science

Preparation for research in computer science. Technical communication skills. Design and evaluation of experiments. The research process.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CS 5024:

Ethics and Professionalism in Computer Science

Ethical implications and consequences of computing technology applied to algorithmic decision making, security, privacy, autonomous systems.

Ethical frameworks and their application to relevant current topics.

Formulating, reasoning, and communicating positions on ethical topics related to computing technology. Diversity and bias as it relates to

information technology. Ethical conduct of research and development of

intellectual property. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

CS 5040:

Intermediate Data Structures and Algorithm Analysis

Data structures and analysis of data structure and algorithm performance. Sorting, searching, hashing, and advanced tree structures and algorithms. File system organization and access methods. Course projects develop advanced problem-solving, design, and implementation skills. Pre: Graduate standing in Computer Science and an undergraduate second semester programming course.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CS 5044:

Object-Oriented Programming with Java

Object-oriented programming concepts and the Java programming language. The application of design strategies, notations, and patterns related to object-oriented systems. Techniques and libraries for developing applications related to the World Wide Web. Credit will not be given for both 2704 and 5044. Not for Computer Science major or minor credit; not for graduate credit for CSA or INFS programs. Pre: Proficiency in a high-level programming language (e.g., FORTRAN, C, C++, or Java) equivalent to 1044 and prior course work, practical training, or work experience related to developing computer software and systems.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CS 5045:

Computation for the Data Sciences

Two course series covering fundamentals of computer science and background in data sciences needed by graduate students without a computer science background. 5045: Python; programming language syntax and semantics; abstraction and object-oriented programming; data structures; algorithms and algorithm analysis; databases. 5046: Software engineering; data preprocessing; and machine learning. Not for CS major or minor credit; not for graduate credit in CSA program. Pre: Graduate standing; 5045 for 5046.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CS 5046:

Computation for the Data Sciences

Two course series covering fundamentals of computer science and background in data sciences needed by graduate students without a computer science background. 5045: Python; programming language syntax and semantics; abstraction and object-oriented programming; data structures; algorithms and algorithm analysis; databases. 5046: Software engineering; data preprocessing; and machine learning. Not for CS major or minor credit; not for graduate credit in CSA program. Pre: Graduate standing; 5045 for 5046.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): CS 5045

Corequisite(s):

CS 5104:

Computability and Formal Languages

Formal theory of computability, the halting problem, models of computation, and Church's thesis, and formal languages.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): CS 5034

Corequisite(s):

CS 5114:

Theory of Algorithms

Methods for constructing and analyzing algorithms. Measures of computational complexity, determination of efficient algorithms for a variety of problems such as searching, sorting and pattern matching. Geometric algorithms, mathematical algorithms, and theory of NP-completeness.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): CS 2604

Corequisite(s):

CS 5124:**Algorithms in Bioinformatics**

Algorithms to solve problems found in biology, especially molecular biology. A variety of current problems in computational molecular biology will be introduced, investigated, analyzed for computational complexity, and solved with efficient algorithms, when feasible. A number of such problems will be shown to be intractable or other evidence of their difficulty will be presented. Prerequisites or graduate standing in CSA required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): (CS 4104 (UG) OR CS 5046 (UG), PPWS 5314 (UG)) OR (CS 4104 OR CS 5046, PPWS 5314)

Corequisite(s):

CS 5204:**Operating Systems**

Issues in the design and functioning of operating systems. Emphasis on synchronization of concurrent activity in both centralized and distributed systems. Deadlock, scheduling, performance analysis, operating system design, and memory systems including distributed file systems. Pre:

Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

CS 5214:**Modeling and Evaluation of Computer Systems**

An overview of modeling, simulation, and performance evaluation of computer systems, i.e., operating systems, database management systems, office automation systems, etc. Fundamentals of modeling, the life cycle of a simulation study, workload characterization, random number and variate generation, procurement, measurement principles, software and hardware monitors, capacity planning, system and program tuning, and analytic modeling. Duplication of subject matter of 4214 and 4224. Maximum of 6 hours credit may be obtained from 4214, 4224, 5214.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): (CS 5024 (UG), STAT 4705 (UG)) OR (STAT 4714 (UG), STAT 4105 (UG)) OR (CS 5024, STAT 4705) OR (STAT 4714, STAT 4105)

Corequisite(s):

CS 5234:**Advanced Parallel Computation**

Survey of leading high-end computing systems and their programming environments. Advanced models of parallel computation. Mapping of parallel algorithms to architectures. Performance programming and tools for performance optimization on parallel systems. Execution environments and system software for large-scale parallel computing. Case studies of parallel applications. Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): CS 4234 (UG) OR CS 4234

Corequisite(s):

CS 5244:**Web Application Development**

Languages and technologies needed to develop modern data-centric web applications. Commonly used protocols and standards. Client-side technologies such as HTML, CSS, and JavaScript; server-side technologies such as Servlets and JSP; and database access with SQL. Principles and technologies for web application architecture, electronic commerce, and web application security.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): CS 5044

Corequisite(s):

CS 5254:**Mobile Application Development**

Languages and technologies needed to develop applications for modern mobile devices. Mobile infrastructure and devices. Interactive graphical user interfaces for mobile devices. Protocols and standards for using mobile device features such as sensors, networking, location, camera, and audio. Mobile app architecture, performance considerations, and asynchronous programming. Principles and technologies for mobile security.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): CS 5044

Corequisite(s):

CS 5264G:

Advanced Linux Kernel Programming

Design and internal organization of the Linux operating system kernel. Kernel subsystems, boot process, memory management, process and thread model, scheduling, interrupt and exception handling, virtual file system and the concrete file system, block I/O and I/O scheduler, network stack, and device drivers. Modification of existing kernel code. Design, implementation, test and evaluation of new kernel modules, Kernel and full software stack debugging techniques, and virtualization as an aid for operating system development and debug. Software engineering techniques to analyze, modify and run a large, complex open-source code base. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CS 5304:

Translator Design and Construction

Fundamental theory of parsing and translation and practical applications of this theory. Lexical analysis, parsing techniques based on top-down (LL, Recursive Descent) and bottom-up (LR, Precedence), code generation, code optimization techniques, and runtime systems.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): (CS 4114 (UG) OR CS 5034 (UG)) OR (CS 4114 OR CS 5034)

Corequisite(s):

CS 5314:

Programming Languages

In depth investigation of the principles of programming systems, not necessarily restricted to programming languages, both from the point of view of the user and implementer. Algorithms of implementation, syntax and semantic specification systems, block structures and scope, data abstraction and aggregates, exception handling, concurrency, and applicative/functional/data-flow languages.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): CS 3304 (UG) OR CS 3304

Corequisite(s):

CS 5424 (BIOL 5424) (GBCB 5424):

Computational Cell Biology

Use of mathematical models (nonlinear ordinary differential equations and stochastic processes) and simulation algorithms to explore the complex feedback circuits that control the behavior of living cells. Concepts and techniques from dynamical systems theory, bifurcation analysis, numerical methods, SBML (systems biology markup language) and Matlab programming. Applications in gene regulatory networks, cell cycle control, circadian rhythms, cell signaling.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): MATH 5515

Corequisite(s):

CS 5465:

Numerical Analysis

A survey of the construction, analysis, and implementation of numerical algorithms in linear algebra, nonlinear equations and optimization, approximation by polynomials, quadrature, and ordinary differential equations.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CS 5466:

Numerical Analysis

A survey of the construction, analysis, and implementation of numerical algorithms in linear algebra, nonlinear equations and optimization, approximation by polynomials, quadrature, and ordinary differential equations.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CS 5474 (MATH 5474):**Finite Difference Methods for Partial Differential Equations**

Finite difference methods for initial and boundary value problems for partial differential equations. Consistency, stability, convergence, dispersion, and dissipation. Methods for linear and nonlinear elliptic and parabolic equations, first- and second-order hyperbolic equations, and nonlinear conservation laws.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): CS 3414 (UG) OR CS 3414

Corequisite(s):

CS 5484 (MATH 5484):**Finite Element Methods for Partial Differential Equations**

Weak formulations of boundary-value problems for elliptic partial differential equations. Finite element spaces. Approximation theory for finite element spaces. Error estimates. Effects of numerical integration and curved boundaries. Nonconforming methods. Concrete examples of the application of the finite element method. Efficient implementation strategies. Time dependent problems.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): CS 3414 (UG) OR CS 3414

Corequisite(s):

CS 5485 (MATH 5485):**Numerical Analysis and Software**

Presentation and analysis of numerical methods for solving common mathematical and physical problems. Methods of solving large sparse linear systems of equations, algebraic eigenvalue problems, and linear least squares problems. Numerical algorithms for solving constrained and unconstrained optimization problems. Numerical solutions of nonlinear algebraic systems. Convergence, error analysis. Hardware and software influences. Efficiency, accuracy, and reliability of software. Robust computer codes.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): (MATH 4445 (UG), MATH 4446 (UG)) OR (MATH 4445, MATH 4446)

Corequisite(s):

CS 5486 (MATH 5486):**Numerical Analysis and Software**

Presentation and analysis of numerical methods for solving common mathematical and physical problems. Methods of solving large sparse linear systems of equations, algebraic eigenvalue problems, and linear least squares problems. Numerical algorithms for solving constrained and unconstrained optimization problems. Numerical solutions of nonlinear algebraic systems. Convergence, error analysis. Hardware and software influences. Efficiency, accuracy, and reliability of software. Robust computer codes.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): (MATH 4445 (UG), MATH 4446 (UG)) OR (MATH 4445, MATH 4446)

Corequisite(s):

CS 5504 (ECE 5504):**Computer Architecture**

Advanced computer architectures, focusing on multiprocessor systems and the principles of their design. Parallel computer models, programming and interconnection network properties, principles of scaleable designs. Case studies and example applications of pipeline processors, interconnection networks, SIMD and MIMD processors.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): CS 4504 (UG) OR CS 4504

Corequisite(s):

CS 5510 (ECE 5510):**Multiprocessor Programming**

Principle and practice of multiprocessor programming. Illustration of multiprocessor programming principles through the classical mutual exclusion problem, correctness properties of concurrency (e.g., linearizability), shared memory properties (e.g. register constructions), and synchronization primitives for implementing concurrent data structures (e.g., consensus protocols). Illustration of multiprocessor programming practice through programming patterns such as spin locks, monitor locks, the work-stealing paradigm and barriers. Discussion of concurrent data structures (e.g., concurrent linked lists, queues, stacks, hash maps, skiplists) through synchronization patterns ranging from coarse-grained locking to fine-grained locking to lock-free structures atomic synchronization primitives, elimination, and transactional memory.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECE 4534 OR ECE 4550

Corequisite(s):

CS 5525 (STAT 5525):

Data Analytics

5525: Basic techniques in data analytics including the preparation and manipulation of data for analysis and the creation of data files from multiple and dissimilar sources. The data mining and knowledge discovery process. Overview of data mining algorithms in classification, clustering, association analysis, probabilistic modeling, and matrix decompositions. Detailed study of classification methods including tree-based methods, Bayesian methods, logistic regression, ensemble, bagging and boosting methods, neural network methods, use of support vectors and Bayesian networks. Detailed study of clustering methods including k-means, hierarchical and self-organizing map methods.

Prerequisite: Graduate Standing required. 5526: Techniques in unsupervised and visualized learning in high dimension spaces.

Theoretical, probabilistic, and applied aspects of data analytics. Methods include generalized linear models in high dimensional spaces, regularization, lasso and related methods, principal component regression (pca), tree methods, and random forests. Clustering methods including k-means, hierarchical clustering, biclustering, and model-based clustering will be thoroughly examined. Distance-based learning methods include multi dimensional scaling, the self organizing map, graphical/network models, and isomap. Supervised learning will consist of discriminant analyses, supervised pca, support vector machines, and kernel methods.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CS 5526 (STAT 5526):

Data Analytics

5526: Basic techniques in data analytics including the preparation and manipulation of data for analysis and the creation of data files from multiple and dissimilar sources. The data mining and knowledge discovery process. Overview of data mining algorithms in classification, clustering, association analysis, probabilistic modeling, and matrix decompositions. Detailed study of classification methods including tree-based methods, Bayesian methods, logistic regression, ensemble,

bagging and boosting methods, neural network methods, use of support vectors and Bayesian networks. Detailed study of clustering methods including k-means, hierarchical and self-organizing map methods.

Prerequisite: Graduate Standing required. 5526: Techniques in unsupervised and visualized learning in high dimension spaces.

Theoretical, probabilistic, and applied aspects of data analytics. Methods include generalized linear models in high dimensional spaces, regularization, lasso and related methods, principal component regression (pca), tree methods, and random forests. Clustering methods including k-means, hierarchical clustering, biclustering, and model-based clustering will be thoroughly examined. Distance-based learning methods include multi dimensional scaling, the self organizing map, graphical/network models, and isomap. Supervised learning will consist of discriminant analyses, supervised pca, support vector machines, and kernel methods.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): CS 5525 OR STAT 5525

Corequisite(s):

CS 5560 (ECE 5560):

Fundamentals of Info Security

Principles of information security and relevant mathematical concepts. Classical ciphers, relevant abstract algebra and number theory, symmetric-key ciphers, cipher modes of operation, and asymmetric-key ciphers. Cryptographic hash functions and message authentication codes. Elliptic curve cryptography and cryptosystems. Applications and standards relevant to network and computer security. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

CS 5565 (ECE 5565):

Network Architecture and Protocols

5565: Principles and concepts of networking and protocols, with emphasis on data link, network, and transport protocols. Contemporary and emerging networks and protocols to illustrate concepts and to provide insight into practical networks including the Internet. Quantitative and qualitative comparisons of network architectures and protocols.

5566: Performance evaluation, design, and management of networks.

Use of queuing and other analytical methods, simulation, and

experimental methods to evaluate and design networks and protocols.
Network management architectures and protocols. Graduate standing in EE, ECE, CS, or IT required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): STAT 4714 (UG) OR STAT 4714

Corequisite(s):

CS 5566 (ECE 5560):

Network Architecture and Protocols

5565: Principles and concepts of networking and protocols, with emphasis on data link, network, and transport protocols. Contemporary and emerging networks and protocols to illustrate concepts and to provide insight into practical networks including the Internet. Quantitative and qualitative comparisons of network architectures and protocols.

5566: Performance evaluation, design, and management of networks.

Use of queuing and other analytical methods, simulation, and experimental methods to evaluate and design networks and protocols.

Network management architectures and protocols. Graduate standing in EE, ECE, or IT is required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): CS 5565 (UG) OR CS 5565

Corequisite(s):

CS 5580:

Cryptographic Engineering

Implementation of cryptographic operations and protocols in contemporary computing platforms. Mapping of cryptographic operations, evaluation and optimization of performance and implementation cost, analysis of security against brute-force cryptanalysis and implementation-level attacks. Design of countermeasures against implementation-level attacks, security-testing procedures, and architectures to support a trusted computing base.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECE 5560 OR CS 5560

Corequisite(s):

CS 5584 (ECE 5584):

Network Security

Fundamentals of network security. Network security architecture, user and attacker perspective. Practical applications and security standards. Protocol design principles and their impact on computer and network security. Authentication systems. Email security. Firewalls and intrusion detection. Security for wireless systems.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): CS 5560 OR ECE 5560

Corequisite(s):

CS 5590 (ECE 5590):

System and Software Security

Secure software design, memory and file system security, operating system security for various platforms. Program classification, anomaly detection, malware detection and analysis. Technical challenges and problems in securing operating systems and software. Classic and modern algorithms, models, principles, and tools for system and application software security. Actual security examples.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): CS 5560 OR ECE 5560

Corequisite(s):

CS 5594:

Blockchain Technologies

Principles of an open, distributed ledger. Underlying data structures and algorithms such as cryptographic hashing and Merkle trees, consensus algorithms, and Byzantine agreement. Bitcoin as an exemplar. Proof of work and proof of stake. Applications including cryptocurrencies, financial ledgers, and smart contracts. Pre: Graduate standing in Computer Science.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CS 5604:

Information Storage and Retrieval

Analyzing, indexing, representing, storing, searching, retrieving, processing and presenting information and documents using fully automatic systems. The information may be in the form of text,

hypertext, multimedia, or hypermedia. The systems are based on various models, e.g., Boolean logic, fuzzy logic, probability theory, etc., and they are implemented using inverted files, relational thesauri, special hardware, and other approaches. Evaluation of the systems efficiency and effectiveness. Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CS 5614:

Database Management Systems

Emphasizes concepts, data models, mechanisms, and language aspects concerned with the definition, organization, and manipulation of data at a logical level. Concentrates on relational model, along with introduction to design of relational systems using Entity-relationship modeling.

Functional dependencies and normalization of relations. Query languages, relational algebra, Datalog, and SQL. Query processing, logic and databases, physical database tuning. Concurrency control, OLTP, active and rule-based elements. Data Warehousing, OLAP.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): CS 2604 (UG) OR CS 2604

Corequisite(s):

CS 5644:

Machine Learning with Big Data

Basic principles and techniques for big data analytics, including methods for storing, searching, retrieving, and processing large datasets; introduction to basic machine learning libraries for analyzing large datasets; data visualization; case studies with real-world datasets. Not for graduate credit for degrees in Computer Science and Applications (CSA).

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): CS 5044

Corequisite(s):

CS 5664:

Social Media Analytics

Social media platforms, media feeds, and data formats; machine

learning and graph theory foundations of social media analytics; Forms of social media analytics - text analytics, network analytics, and action analytics; Forecasting models and applications, including in marketing, event tracking, surveying, and A/B testing. Not for graduate credit for degrees in Computer Science and Applications (CSA).

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): CS 5644

Corequisite(s):

CS 5704:

Software Engineering

Study of the principles and tools applicable to the methodical construction and controlled evolution of complex software systems. All phases of the life cycle are presented; particular attention focuses on the design, testing, and maintenance phases. Introduction to software project management. Attention to measurement models of the software process and product which allow quantitative assessment of cost, reliability, and complexity of software systems.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): CS 5044

Corequisite(s):

CS 5714 (ISE 5714):

Usability Engineering

Design and evaluation of effective user interfaces, beginning with principles for designing the product. Development process for user interaction separate from interactive software development.

Development process includes iterative life cycle management, systems analysis, design, usability specifications, design representation techniques, prototyping, formative user-based evaluation. Integrative and cross-disciplinary approach with main emphasis on usability methods and the user interaction development process.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CS 5724:

Models and Theories of Human-computer Interaction

Survey of models and theories of users and their use of computer equipment; conditions of application for various approaches. Task analysis, task modeling, representations and notations.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CS 5734:

Social Computing and Computer-Supported Cooperative Work

Social computing and cooperative work situations. Design implementation, use and analysis of computing systems concerned with multiple users and stakeholders. Analytic practices and application of human behavior theories for social computing. Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CS 5744:

Software Design and Quality

This course focuses on critical aspects of the software lifecycle that have significant influence on the overall quality of the software system including techniques and approaches to software design, quantitative measurement and assessment of the system during implementation, testing, and maintenance, and the role of verification and validation in assuring software quality.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): CS 5704 (UG) OR CS 5704

Corequisite(s):

CS 5754:

Virtual Environments

Introduction to the theory and practice of three-dimensional virtual environments (VEs). 3D input and output devices, applications of VEs, 3D user interfaces and human-computer interaction, 3D graphics techniques for VEs, 3D modeling and level of detail, evaluation of VEs, VE software systems and standards, collaborative and distributed VEs. Includes hands-on experience with VE hardware and software.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CS 5764:

Information Visualization

Examine computer-based strategies for interactive visual presentation of information that enable people to explore, discover, and learn from vast quantities of data. Learn to analyze, design, develop, and evaluate new visualizations and tools. Discuss design principles, interaction strategies, information types, and experimental results. Research-oriented course surveys current literature, and group projects contribute to the state of the art. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

CS 5774:

User Interface Software

Survey of software architectures to build user interfaces, particularly focused on graphical user interfaces. Includes the design and implementation of user interfaces, the use of object-oriented application frameworks, software architecture for command undo, document management, layout managers, customized components, and separation of concerns in user interface software architectures. Discussion of research and advanced topics in User Interface Software.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): CS 2704 (UG) OR CS 2704

Corequisite(s):

CS 5804:

Introduction to Artificial Intelligence

A graduate level overview of the areas of search, knowledge representation, logic and deduction, learning, planning, and artificial intelligence applications.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

333 Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): CS 2604 (UG) OR CS 2604

Corequisite(s):

CS 5814:

Introduction to Deep Learning

History and basic concepts of artificial neural networks. Activation functions, optimization methods and regularization strategies used in deep multi-layered networks. Network architectures such as convolutional networks and recurrent neural networks. Deep reinforcement learning algorithms including deep Q-learning and policy gradient methods. Deep unsupervised models such as auto-encoders, and deep generative models including variational auto-encoders and generative adversarial networks. Encoder-decoder architectures and their applications in real-world problems such as machine translation, image captioning, visual question answering, and text summarization. Duplicates ECE 6524 (CS 6524).

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): CS 5525 OR CS 5824

Corequisite(s):

CS 5824 (ECE 5424):

Advanced Machine Learning

Algorithms and principles involved in machine learning; focus on perception problems arising in computer vision, natural language processing and robotics; fundamentals of representing uncertainty, learning from data, supervised learning, ensemble methods, unsupervised learning, structured models, learning theory and reinforcement learning; design and analysis of machine perception systems; design and implementation of a technical project applied to real-world datasets (images, text, robotics). Pre: Graduate Standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CS 5834:

Introduction to Urban Computing

Computational approaches to address urban challenges; sensor network testbeds; algorithms for storing, processing, and mining data from urban settings; communicating patterns to decision makers; special focus on epidemiology, sustainability, transportation, social science, urban economics; case studies with applications. Pre: Graduate Standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CS 5854:

Computational Systems Biology

Phenomenological and data-driven models of molecular interaction networks. Applications of graph theory, discrete algorithms, data mining, and machine learning to the modeling and analysis of molecular interaction networks. Biological applications. Interaction between biological and computational disciplines in systems biology. Must have GBCB pre-requisite and CS pre-requisites or graduate standing in CSA or equivalent.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): CS 4104 (UG) OR CS 4104 OR CS 5046, GBCB 5314

Corequisite(s):

CS 5894:

Final Examination

NONE

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CS 5904:

Project and Report

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research

Instruction Type(s): Research

Prerequisite(s):

Corequisite(s):

CS 5934:

Capstone Project

Design, implementation, and communication of a software system throughout the product lifecycle. Current software product development

models. Product ideation, end-user and stakeholder analysis. Product development targeted to market need. Communication of design and goals. Use of appropriate development tools. Pre: Graduate standing in Computer Science.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CS 5944:

Graduate Seminar

NONE

Credit Hour(s): 1

Lecture Hour(s): 1

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CS 5974:

Independent Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Independent Study

Instruction Type(s): Independent Study

Prerequisite(s):

Corequisite(s):

CS 5984:

Special Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CS 5994:

Research and Thesis

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research, Online Research

Instruction Type(s): Research, Online Research

Prerequisite(s):

Corequisite(s):

CS 6104:

Advanced Topics in Theory of Computation

This course treats a specific, advanced topic of current research interest in the area of theory of computation. Papers from the current literature or research monographs are likely to be used instead of a textbook.

Student participation in a seminar style format may be expected. May be repeated with different content for a maximum of nine credit hours.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): CS 5104 (UG) OR CS 5114 (UG) OR CS 5104 OR CS 5114

Corequisite(s):

CS 6204:

Advanced Topics in Systems

This course treats a specific advanced topic of current research interest in the area of systems. Papers from the current literature or research monographs are likely to be used instead of a textbook. Student participation in a seminar style format may be expected. May be repeated with different content for a maximum of nine credit hours.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): CS 5204 (UG) OR CS 5214 (UG) OR CS 5204 OR CS 5214

Corequisite(s):

CS 6304:

Advanced Topics in Languages and Translation

This course treats a specific advanced topic of current research interest in the area of languages and translation. Papers from the current literature or research monographs are likely to be used instead of a textbook. Student participation in a seminar style format may be expected. May be repeated with different content for a maximum of nine credit hours.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

335 Prerequisite(s): CS 5304 (UG) OR CS 5314 (UG) OR CS 5304 OR CS

5314

Corequisite(s):

CS 6404:

Advanced Topics in Mathematical Software

This course treats a specific advanced topic of current research interest in the area of mathematical software. Papers from the current literature or research monographs are likely to be used instead of a textbook.

Student participation in a seminar style format may be expected. May be repeated with different content for a maximum of nine credit hours.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): CS 5485 (UG) OR CS 5485

Corequisite(s):

CS 6424:

PGMs and Structured Prediction

Advanced concepts in machine learning. Probabilistic graphical models and structured output prediction. Directed models (Bayes Nets), undirected models (Markov/Conditional Random Fields), exact inference (junction tree), approximate inference (belief propagation, dual decomposition), parameter learning (MLE, MAP, EM, max-margin), structure learning.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECE 5424G OR CS 5824

Corequisite(s):

CS 6444 (ME 6444) (AOE 6444):

Verification and Validation in Scientific Computing

Applicable to scientific and engineering models described by partial differential or integral equations. Software engineering, code verification, and the method of manufactured solutions for generating exact solutions. Estimation of numerical approximation errors in scientific computing. Design and execution of experiments for model validation and model accuracy assessment. Propagation of aleatory and epistemic uncertainty through models. Estimation of total prediction uncertainty in scientific computing simulations. Graduate Standing required

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CS 6504:

Advanced Topics in Computer Architecture

This course treats a specific advanced topic of current research interest in the area of architecture. Papers from the current literature or research monographs are likely to be used instead of a textbook. Student participation in a seminar style format may be expected. May be repeated with different content for a maximum of nine credit hours.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): CS 5515 (UG) OR CS 5516 (UG) OR CS 5515 OR CS 5516

Corequisite(s):

CS 6524 (ECE 6524):

Deep Learning

Advanced concepts in Machine Learning and Deep Learning. Models (multi-layer perceptrons, convolutional neural networks, memory networks), learning algorithms (backpropagation, stochastic sub-gradient descent, dropout), connections to structured predictions (Boltzmann machines, unrolled belief propagation), and applications to perception and Artificial Intelligence (AI) problems (image classification, detection, and segmentation; image captioning; visual question answering; automatic game playing).

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECE 5424G OR CS 5824

Corequisite(s):

CS 6564 (ECE 5584):

Multimedia Networking

This course examines and explores recent advances in multimedia networking technologies. Major topics include multimedia compression and standards, quality of service (QoS) support mechanisms and protocols, performance analysis, network calculus, IP multicasting, Internet multimedia applications, and multimedia transport over wireless networks.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

336 Prerequisite(s): CS 5565 (UG) OR CS 5565

Corequisite(s):

CS 6570:

Advanced Foundations of Networking

This course covers theoretical foundations that are necessary for advanced study of networking. It focuses on algorithm design and optimization techniques that are most commonly used to solve complex networking problems. Major topics include complexity analysis with applications to networking problems, design and proof of approximation algorithms, design of meta-heuristic algorithms, formulation techniques for network optimization, linear and non-linear optimization techniques with applications to networking, design of distributed algorithms with proof of convergence for networks systems.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): CS 5565 (UG) OR ECE 5565 (UG) OR CS 5565 OR ECE 5565

Corequisite(s):

CS 6604:

Advanced Topics in Data and Information

This course treats a specific advanced topic of current research interest in the area of data and information. Papers from the current literature or research monographs are likely to be used instead of a textbook. Student participation in a seminar style format may be expected. May be repeated with different content for a maximum of nine credit hours.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): CS 5604 (UG) OR CS 5614 (UG) OR CS 5604 OR CS 5614

Corequisite(s):

CS 6704:

Advanced Topics in Software Engineering

This course treats a specific advanced topic of current research interest in the area of software engineering. Papers from the current literature or research monographs are likely to be used instead of a textbook. Student participation in a seminar style format may be expected. May be repeated with different content for a maximum of nine credit hours.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): CS 5704 (UG) OR CS 5714 (UG) OR CS 5704 OR CS 5714

Corequisite(s):

CS 6724:

Advanced Topics in Human-computer Interaction

Addresses a specific advanced topic of current research interest in the area of human-computer interaction (HCI). Research monographs and papers from the current literature will be used as a source of material too new yet to be in a textbook. Student participation in a seminar-style format. Each offering of this course will address a different subtopic area of HCI. May be repeated for credit.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): CS 5714 (UG) OR CS 5724 (UG) OR CS 5734 (UG) OR CS 5714 OR CS 5724 OR CS 5734

Corequisite(s):

CS 6804:

Advanced Topics in Intelligent Systems

This course treats a specific advanced topic of current research interest in the area of intelligent systems. Papers from the current literature or research monographs are likely to be used instead of a textbook. Student participation in a seminar style format may be expected. May be repeated with different content for a maximum of nine credit hours.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): CS 5804 (UG) OR CS 5814 (UG) OR CS 5804 OR CS 5814

Corequisite(s):

CS 6824:

Adv Topics Comp Biol & Bioinf

Addresses a specific advanced topic of current research interest in the area of computational biology and bioinformatics (CBB). Research monographs and papers from the current literature used as a source of material too new to be discussed in a textbook. Student participation in a seminar-style format. Each offering of this course will address a different subtopic area of CBB. May be repeated with different content for a maximum of 12 credit hours. Pre: Graduate standing; other prerequisites may apply.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CS 7994:

Research and Dissertation

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research

Instruction Type(s): Research

Prerequisite(s):

Corequisite(s):

ELECTRICAL ENGINEERING

Luke Lester, Head

Emeriti Faculty: Robert Broadwater; Gary Brown; William Davis; Fred Lee;

Douglas Lindner; Arun Phadke; Krishnan Ramu; Warren Stutzman;

Professors: Amos Abbott; Masoud Agah; Paul Ampadu; Peter Athanas; Scott

Bailey; Joseph Baker; Aloysius Beex; Dushan Boroyevich; Richard Buehrer;

Rolando Burgos; C Clauer; Gregory Earle; Dong Ha; Yiwei Hou; Michael Hsiao;

Mark Jones; Jih Lai; Luke Lester; Chen-Ching Liu; Guo Quan Lu; Thomas Martin;

Scott Midkiff; Lamine Mili; Khai Ngo; Mariusz Orlowski; Jung-Min Park; Paul

Plassmann; Ting Chung Poon; Saifur Rahman; Binoy Ravindran; Jeffrey Reed;

John Ruohoniemi; Walid Saad; Ahmad Safaai-Jazi; Timothy Sands; Wayne Scales;

Leonard Smith; Angelos Stavrou; Daniel Stilwell; Joseph Tront; Yue Wang; Anbo

Wang; Yong Xu; Jianhua Xuan; Yaling Yang;

Associate Professors: William Baumann; Virgilio Centeno; Jaime De La

Reelopez; Harpreet Singh Dhillon; Steven Ellingson; Louis Guido; Mantu Hudait;

Qiang Li; Lingjia Liu; Majid Manteghi; Ali Mehrizi-Sani; Leyla Nazhandali; Cameron

Patterson; JoAnn Paul; Chris Wyatt; Yang Yi; Guoqiang Yu;

Assistant Professors: Thidapat Chantem; Christina Dimarino; Tinh Doan; Dong

Dong; Ryan Gerdes; Mona Ghassemi; Jia-Bin Huang; Xiaoting Jia; Ruoxi Jia; Ming

Jin; Vasileios Kekatos; Elena Lind; Chang Woo Min; Pratap Tokekar; Ryan

Williams; Haibo Zeng; Yuhao Zhang; Wei Zhou; Yizheng Zhu;

Grant A. Dove Professor: Yue Wang;

Virginia Microelectronics Consortium Professor of Engineering: Masoud

Agah;

Bradley Distinguished Professor: Yiwei Hou;

James S. Tucker Professor: Jih Lai;

Willis Worcester Professor: Jeffrey Reed;

University Distinguished Professor: Dushan Boroyevich; Fred Lee; Arun

Phadke;

Clayton Ayre Professor: Anbo Wang;

Joseph R. Loring Professor: Saifur Rahman;

Bradley Faculty Fellow of Education: Thomas Martin;

J. Byron Maupin Professor of Engineering: Wayne Scales;

Elizabeth and James Turner Faculty Fellow: Harpreet Singh Dhillon;

Roanoke Electric Steel Professorship in Engineering: Luke Lester;

American Electric Power: Chen-Ching Liu;

Collegiate Assistant Professors: Almuatazbellah Boker; Kristie Cooper;

Collegiate Professors: Creed Jones; Vassilios Kovanis; Timothy Talty;

Collegiate Associate Professors: Jeffrey Ransbottom;

Research Professors: Scott Dunning;

Research Assistant Professors: Sook Ha; Mary Lanzerotti;

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Graduate Counseling: eceadvising@vt.edu

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Student Handbook: <http://www.ece.vt.edu/gradman/manual.php>

The Harry Lynde Bradley Department of Electrical and Computer Engineering offers graduate degree programs leading to the Master of Engineering (M.Eng.), Master of Science (M.S.), and Doctor of Philosophy (Ph.D.) in electrical engineering and computer engineering. All degree programs are offered through the Blacksburg campus as well as extended campus consortia (National Capital Region, Northern Virginia Center, Falls Church, Virginia; Central; Hampton Roads; Western, and VT-MENA through Alexandria and Cairo, Egypt). For the master's degree, each plan of study, developed by the student in consultation with his or her faculty advisor, must contain a limited number of core courses. The M.S. degree program requires a thesis. The M.Eng. is a non-thesis degree program and is especially suitable for part-time graduate students employed as engineers by industry and government agencies. The Ph.D. degree program is research-oriented. Applicants applying for these degrees program must have an earned Master's degree in CPE, EE or related field. A direct-Ph.D. option is available for students without an earned Master's degree. These students will earn a Master of Science, Thesis, or Master of Science, Non-Thesis, degree in addition to the Ph.D. The Bradley Department of Electrical and Computer Engineering's current enrollment is approximately 535 students. Out of the enrolled students, approximately 95% of our full-time Ph.D. students are funded and approximately 75% of our full-time Master's student are funded. Funding is available in three ways: Graduate Teaching Assistantships - Awarded by the department Graduate Research Assistantships - Awarded by individual faculty Fellowships - Awarded by the department to the top applicants to the program. Of the fellowships awarded by the department, the Bradley Fellowship is the highest honor bestowed on ECE Ph.D. students and is restricted to U.S. citizens only.

SPECIAL FACILITIES

Well-equipped research facilities, labs, and centers are available within the different research areas. For more information, click here.

DEGREES OFFERED

MEng Degree

TOEFL

Paper: (590.0)

Computer: (243.0)

iBT: (96.0)

GRE

General Test: Verbal (153.0), Quantitative (157.0), Writing (4.5)

IELTS

General: Band (7.5)

32 credit hours 27 credit hours of course work 3 credit hours of project and report 2 credit hours of seminar The ECE Graduate Student Policy Manual gives detailed information pertaining to degree requirements.

MS Degree

TOEFL

Paper: (590.0)

Computer: (243.0)

iBT: (97.0)

GRE

General Test: Verbal (153.0), Quantitative (157.0), Writing (4.5)

IELTS

General: Band (7.5)

32 credit hours 21 credit hours of course work 9 credit hours of research and thesis 2 credit hours of seminar The ECE Graduate Student Policy Manual gives detailed information pertaining to degree requirements.

PhD Degree

Regular PhD Requirements (for students with an earned Masters):92 credit hours 30 credit hours of course work 60 credit hours of research and thesis 2 credit hours of seminar Direct-PhD Requirements (for students with only an earned Bachelors):MS, Thesis and PhD - 92 credit hours 21 credit hours of coursework for MS (all transfer to PhD) 9 additional credit hours of coursework for PhD 9 hours of research and thesis for MS 60 credit hours of research and dissertation for PhD 2 credit of seminar that will count for both MS and PhD MS, Non-Thesis and PhD - 92 credit hours 30 credit hours of coursework for MS (all transfer to PhD) 60 credit hours of research and dissertation for PhD 2 credit of seminar that will count for both MS and PhD The ECE Graduate Student Policy Manual gives detailed information pertaining to degree requirements.

GRADUATE COURSES (ECE)

ECE 5104G:

Advanced Microwave and RF Engineering

Passive and active RF and microwave components and circuits for wireless communications: transmission-line theory; planar transmission-lines and waveguides; S-parameters; resonators; power dividers and couplers; microwave filters; sources, detectors, and active devices; modern RF & microwave CAD. Active RF components. Microwave amplifier design. Microwave Integrated Circuits (MIC). RF

Microelectromechanical System (MEMS) components. Microwave systems. RF components for wireless systems. RF components for Ultra Wide band (UWB) systems. Prerequisite: Graduate Standing required

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ECE 5105:

Electromagnetic Waves

5105: Fundamentals of plane wave propagation, reflection, and transmission; basic theorems, equivalent currents, and Greens theory; radiation fields generated by current sources. 5106: Electromagnetic fields in the presence of inhomogeneous media; separation of variables; analyses of waveguide, cavity, radiation, and scattering problems; numerical methods. Pre: 5105: Graduate standing; 5106: 5105.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

ECE 5106:

Electromagnetic Waves

5105: Fundamentals of plane wave propagation, reflection, and transmission; basic theorems, equivalent currents, and Greens theory; radiation fields generated by current sources. 5106: Electromagnetic fields in the presence of inhomogeneous media; separation of variables; analyses of waveguide, cavity, radiation, and scattering problems; numerical methods. Pre: 5105:Graduate standing; 5106: 5105.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECE 5105

Corequisite(s):

ECE 5134G:

Advanced Fiber Optics and Applications

Theory of optical fiber waveguide propagation and design applications in communication and sensing systems. Pre-requisite: Graduate Standing required

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ECE 5144:

Introduction to Electro-Optics

Physical optics, wave propagation in inhomogeneous media, acousto-optic and electro-optic effects and their applications in intensity modulation and phase modulation of laser beams. Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): (ECE 3106 (UG), ECE 3614 (UG)) OR (ECE 3106, ECE 3614)

Corequisite(s):

ECE 5164 (AOE 5654):

Introduction to Space Science I: The Solar Wind and Magnetosphere

Describes the space environment from the sun to the earth's upper atmosphere. Fundamental concepts in space plasma physics will be presented, as needed, throughout the course. Numerous examples of observations and data will be utilized to illustrate the environment and its dynamic variability. An emphasis will be placed on the practical impacts of this environment and its dynamic variability. An emphasis will be placed on the practical impacts of this environment (space weather) on modern technologies such as solid state devices, satellite technology, communication and global navigation systems.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECE 3106 (UG) OR ECE 3106

Corequisite(s): ECE 5105

ECE 5174 (AOE 5174):

Introduction to Plasma Science

Underlying physical processes and basic computational techniques for laboratory, space, and technological plasma environments including single particle motion, fluid and kinetic theory of plasmas, plasma waves and instabilities, diffusion and resistivity, and nonlinear effects. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ECE 5194:

Remote Sensing: Principles and Techniques

Physical principles involved in remote sensing of Earth's environment and their implementation in engineering systems; societal applications of remote sensing; fundamental principles of electromagnetic wave propagation and scattering; passive versus active techniques; remote sensing platforms and systems integration; advanced concepts important for the design and analysis of remote sensing engineering systems. Pre: Graduate Standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ECE 5200 (MSE 5200):

Semiconductor Alloys and Heterstructures

Advanced treatment of semiconductor materials with an emphasis on binary compounds, ternary and quaternary alloys, and strained-layer structures. Topics include crystal structure; lattice vibrations and phonons; energy band structure; equilibrium and non-equilibrium carrier distributions; electron and hole transport via diffusion and drift; and carrier generation and recombination mechanisms. Graduate standing required in the College of Engineering or College of Science.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): MSE 3204 (UG) OR ECE 4214 (UG) OR PHYS 3455 (UG) OR ECE 4214 OR MSE 3204 OR PHYS 3455

Corequisite(s):

ECE 5204:

Power Semiconductor Devices

Characteristics, fabrication, and application of power semiconductor devices, which may include p-i-n and Schottky diodes, insulated gate bipolar transistors, field effect transistors, and thyristors. Effect of semiconductor material, device structure, and current injection levels on device performance. Device drive requirements and power circuit interaction. Implementation of power devices using wide band gap

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECE 5200

Corequisite(s):

ECE 5205:

Basic Semiconductor Devices

Description of the performance characteristics and limitations of basic semiconductor electronic devices in terms of the properties of semiconductor materials and device structure.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ECE 5210:

MicroElectroMechanical Systems: From Fabrication to Application

MicroElectroMechanical Systems (MEMS) are very-small systems or systems made of very small components. The course focuses on the design, fabrication, and application of microsystems providing a unique opportunity for interdisciplinary interactions. The course consists of lectures, readings from the current literature, discussion by students, and team-work projects. The major topics covers are: materials in MEMS; microfabrication techniques; sensing and actuating mechanisms; wafer-level packaging; and case-study of some MEMS-based devices and lab-on-a-chip systems. Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECE 4234 (UG) OR ECE 4234 OR BCHM 4124 (UG) OR BCHM 4124 OR CHE 4114 (UG) OR CHE 4114 OR CHEM 4124 (UG) OR CHEM 4124 OR ESM 4014 (UG) OR ESM 4014 OR ESM 4024 (UG) OR ESM 4024 OR ME 4304 (UG) OR ME 4304 OR ME 4404 (UG) OR ME 4404 OR MSE 4254 (UG) OR MSE 4254 OR MSE 4354 (UG) OR MSE 4354

Corequisite(s):

ECE 5220:

Radio Frequency Integrated Circuit Technology and Design

Integrated circuit (IC) implementation of RF circuits for wireless communications applications. Transceiver architectures for current wireless communications standards; active/passive device technologies

for RFIC implementations; low noise amplifiers; mixers; frequency sources; power amplifiers; single-chip radios; and RFIC packaging and testing. Case studies of modern RFIC chip sets for current wireless communications standards are examined. The course involves circuit design at the IC level; modern RF/microwave CAD software will be used in conjunction with the course. Design of a wireless transceiver functional block component RFIC chip. Alternate years.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): (ECE 3204 (UG), ECE 3614 (UG)), (ECE 4605 (UG) OR ECE 4104 (UG)) OR (ECE 3204, ECE 3614), (ECE 4605 OR ECE 4104)

Corequisite(s):

ECE 5234:

Emi and Noise Reduction Techniques and Filter Design

Theory and practice of electromagnetic interference (EMI) noise coupling; techniques for noise reduction; shielding, grounding and filtering. Limitations of circuit theory, parasitics in circuits and their physical origins, measurement of EMI to comply with government regulation. EMI problems and solutions to switching power supply applications. Design of EMI filter, magnetics design, eddy currents. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

ECE 5244:

Advanced Power Conversion Techniques

High-frequency resonant, quasi-resonant, and multi-resonant power conversion techniques; zero-voltage and zero-current switching techniques in pulse-width modulation converters and inverters. Pulse-width modulation and frequency modulation; non-linear analysis techniques for resonant and soft-switching converters and inverters. Power factor correction rectifiers and distributed power systems.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECE 4224 (UG) OR ECE 4224

Corequisite(s):

ECE 5254:**Power Converter Modeling and Control**

Nonlinear modeling of power conversion circuit using discrete and average techniques analysis and design of voltage mode and current mode control; parallel module operation and system interactions; distributed power systems; time domain simulation and frequency domain measurement techniques.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECE 4224 (UG) OR ECE 4224

Corequisite(s):

ECE 5264:**Advanced Power Electronics Laboratory**

Study of advanced control and high frequency modeling of power converters; analysis and design of high-frequency power converters; analysis of high-frequency magnetic components; analysis and design of embedded power management solutions for distributed power systems.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECE 5254

Corequisite(s):

ECE 5274:**Modeling and Control of Three-Phase PWM Converters**

Power conversion principles for three-phase pulse-width modulation techniques, control and converters. Development of averaged models of three-phase rectifiers and inverters in stationary and rotating coordinates. Small-signal models in rotating coordinates and control design. Introduction of switching state vectors and different modulation schemes. Three-phase inverter and rectifier applications. Parallel and multi-level three-phase converters. Alternate years. Prerequisite or equivalent.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECE 4224 (UG) OR ECE 4224

Corequisite(s):

ECE 5284:**Energy Harvest Circuit Design**

Energy sources for energy harvesting. Equivalent circuits for various

transducers including piezoelectric (PZT), electromagnetic generators, photovoltaic cells, and thermoelectric generators. Power management circuits (PMCs) and maximum power point tracking (MPPT) schemes for piezoelectric cantilevers. PMCs for electromagnetic and electrostatic generators, and photovoltaic modules. MPPT schemes for photovoltaic modules under full sun and partial shading. Pre: Graduate Standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ECE 5314:**Power System Operation and Control**

A course dealing with modern power system operational and control problems and solution techniques. State estimation, contingency analysis, load-frequency control, and automatic generation control. Load flow analysis and external equivalents for steady-state operations.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECE 4334 (UG) OR ECE 4334

Corequisite(s):

ECE 5324:**Power System Planning**

A study of generation planning, bulk power supply systems, production costing analysis, and load forecasting. Dispersed generation. Electric power system reliability and stability.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECE 4334 (UG) OR ECE 4334

Corequisite(s):

ECE 5334:**Electric Machines and Transients**

Development of inductances, flux linkages, voltage equations, linear transformations, continuous simulation techniques, and machine models. Transients on transmission lines, transformers, and machines. Arcing and restriking phenomena. Lightning arresters and insulation coordination.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECE 4314 (UG) OR ECE 4314

Corequisite(s):

ECE 5374G:

Adv Alternate Energy Systems

Electric energy from alternative energy sources including solar, wind, hydro, biomass, geothermal and ocean. Characteristics of direct conversion, electromechanical conversion, and storage devices used in alternative energy systems. Power system issues associated with integration of small-scale energy sources into the electricity grid. System level cost benefit analysis. Prerequisite: Graduate Standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ECE 5414G:

Advanced Linux Kernel Programming

Design and internal organization of the Linux operating system kernel. Kernel subsystems, boot process, memory management, process and thread model, scheduling, interrupt and exception handling, virtual file system and the concrete file system, block I/O and I/O scheduler, network stack, and device drivers. Modification of existing kernel code. Design, implementation, test and evaluation of new kernel modules, Kernel and full software stack debugging techniques, and virtualization as an aid for operating system development and debug. Software engineering techniques to analyze, modify and run a large, complex open-source code base. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ECE 5424 (CS 5824):

Advanced Machine Learning

Algorithms and principles involved in machine learning; focus on perception problems arising in computer vision, natural language processing and robotics; fundamentals of representing uncertainty, learning from data, supervised learning, ensemble methods, unsupervised learning, structured models, learning theory and reinforcement learning; design and analysis of machine perception

systems; design and implementation of a technical project applied to real-world datasets (images, text, robotics). Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ECE 5434:

Cyber-Physical Systems

Modeling formalism of Cyber-Physical Systems (CPS). Modeling of physical and cyber systems; software synthesis from these modeling formalisms; supporting operating systems and hardware architectures for CPS; critical requirements of CPS and their validation/verification; and CPS case studies. Pre: Graduate Standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ECE 5444:

Advanced Technological Singularity

Investigation, conceptualization and analysis of Technological Singularity -- the potential impact of true artificial machine intelligence on engineering and society. Historical perspectives. Barriers to whole brain emulation and the engineering of superintelligence. The role of consciousness in achieving true machine intelligence. Potential scenarios if superintelligence would come into being. Pre: Graduate Standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ECE 5454:

Optimization Techniques for Electrical and Computer Engineering

Convex optimization theory and algorithms and their application to electrical and computer engineering. Sparse optimization methods, eigen-decomposition techniques, the expectation-maximizing algorithms, stochastic optimization techniques, and special techniques relevant to large-scale optimization.

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECE 5605

Corequisite(s):

ECE 5480:

Cybersecurity and the Internet of Things

Cybersecurity principles and technologies motivated by the evolving ecosystem of Internet of Things (IoT): devices, operating systems, sensors, data storage, networking and communication protocols, and system services. IoT device and system security and privacy vulnerabilities, analysis, and attack mitigation techniques. Master of Information Technology (MIT) students only.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECE 5484 OR CS 5044

Corequisite(s):

ECE 5484:

Fundamentals of Computer Systems

Fundamental principles and concepts of computer systems. Computer hardware; Boolean logic; number systems and representation; design and operation of digital logic; analysis of instruction set architectures and computer organization; and specification of data communication and networking standards. Master of Information Technology (MIT) students only. Pre: Graduate Standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ECE 5485:

Networks and Protocols

5485: Fundamental principles and concepts of computer networks; application, transport, network, and data link protocols. Contemporary and emerging networks; Internet protocols. Principles of quality of service, network security, and network management. 5486: Performance evaluation via analysis, simulation, and experimental methods of networks and network protocols. Wireless and mobile network technologies and protocols; wireless local area networks, cellular systems, sensor networks and the Internet of Things (IoT). Mobility in the Internet and application support for mobility. Master of Information

Technology (MIT) students only. Partially duplicates ECE/CS 5565-5566.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECE 5484, CS 5044

Corequisite(s):

ECE 5486:

Networks and Protocols

5485: Fundamental principles and concepts of computer networks; application, transport, network, and data link protocols. Contemporary and emerging networks; Internet protocols. Principles of quality of service, network security, and network management. 5486: Performance evaluation via analysis, simulation, and experimental methods of networks and network protocols. Wireless and mobile network technologies and protocols; wireless local area networks, cellular systems, sensor networks and the Internet of Things (IoT). Mobility in the Internet and application support for mobility. Master of Information Technology (MIT) students only. Partially duplicates ECE/CS 5565-5566.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECE 5485

Corequisite(s):

ECE 5494:

Innovation Pathways in Artificial Intelligence and Machine Learning

Convergence of digital technologies in networked devices, big data, and advanced breakthroughs in artificial intelligence (AI) and machine learning (ML). Meaning, theory, and construction of socio-technical systems. Analysis of technical aspects and opportunities of AI/ML systems in organizations. Technosystem due diligence of advanced AI/ML systems. Assessment of the viability of emerging technological solutions. Social impacts of disruptive change upon individuals, organizations, and society-at-large. Frameworks for the design and implementation of advanced AI/ML systems. Planning for the future of AI/ML. Master of Information Technology (MIT) students only.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECE 5484 OR MGT 5804

Corequisite(s):

Computer Architecture

Advanced computer architectures, focusing on multiprocessor systems and the principles of their design. Parallel computer models, programming and interconnection network properties, principles of scaleable designs. Case studies and example applications of pipeline processors, interconnection networks, SIMD and MIMD processors.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECE 4504 (UG) OR ECE 4504

Corequisite(s):

ECE 5505:

Testing and Verification of Digital Systems

Various topics on digital circuit testing and verification. 5505: digital circuit testing including simulation, test pattern generation, design for testability, built-in-self-test, and diagnosis. Graduate standing in ECE is required. 5506: circuit verification including two-level and multi-level circuit verification, sequential circuit verification, model-checking simulation-based verification, and ATPG-based verification. Graduate standing in ECE required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECPE 4505

Corequisite(s):

ECE 5506:

Testing and Verification of Digital Systems

Various topics on digital circuit testing and verification. 5505: digital circuit testing including simulation, test pattern generation, design for testability, built-in-self-test, and diagnosis. 5506: circuit verification including two-level and multi-level circuit verification, sequential circuit verification, model-checking simulation-based verification, and ATPG-based verification. Graduate standing in ECE required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECPE 4505

Corequisite(s):

ECE 5510 (CS 5510):

Multiprocessor Programming

Principle and practice of multiprocessor programming. Illustration of

multiprocessor programming principles through the classical mutual exclusion problem, correctness properties of concurrency (e.g., linearizability), shared memory properties (e.g. register constructions), and synchronization primitives for implementing concurrent data structures (e.g., consensus protocols). Illustration of multiprocessor programming practice through programming patterns such as spin locks, monitor locks, the work-stealing paradigm and barriers. Discussion of concurrent data structures (e.g., concurrent linked lists, queues, stacks, hash maps, skiplists) through synchronization patterns ranging from coarse-grained locking to fine-grained locking to lock-free structures, atomic synchronization primitives, elimination, and transactional memory. Pre-requisite: Graduate Standing required

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECE 4534 OR ECE 4550

Corequisite(s):

ECE 5514:

Design of Systems on a Chip

Current state of the art in the system-level design of Systems on a Chip. The focus is in hardware, scheduling, and applications at the highest levels of design. Pre-requisite: Graduate Standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECE 4514 (UG) OR ECE 4514

Corequisite(s):

ECE 5520:

Secure Hardware Design

Design and implementation of secure hardware at multiple levels of abstractions, covering cryptographic hardware primitives, cryptographic hardware primitives, cryptographic modules using passive attacks, active attacks, and cryptanalytic techniques. Countermeasures against reverse engineering. The course uses case studies and literature surveys to reflect on the state-of-the-art in secure hardware implementation.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECE 4514 (UG) OR ECE 4514

Corequisite(s):

Electronic Design Automation

This course introduces graduate students to the various design automation artifacts, algorithms, and methodologies. It includes system level design languages, abstractions, models of computation, high level synthesis, modeling and model transformations, and simulation based validation. The course deals with state of the art design practices. It requires a solid back-ground in computer architecture, digital design, and proficiency in programming and modeling.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECE 4514 (UG) OR ECE 4514

Corequisite(s):

ECE 5545:

Advanced VLSI Design

Advanced concepts in CMOS-based digital system are studied. The topics include implementation of special purpose structures for complex digital systems, automation and verification of the design process, and design for testability (5545); and design techniques for low-power design, power dissipation estimation, and application of low-power techniques in the different levels of the design hierarchy (5546).

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECE 4540 (UG) OR ECE 4540

Corequisite(s):

ECE 5550G:

Advanced Real-Time Systems

Theory, algorithmic and protocol concepts, mechanisms, and implementations of real-time computer systems. Introduction to real-time systems, real-time scheduling, real-time synchronization, real-time operating systems kernels, and real-time programming languages. Design and analysis of real-time resource management algorithms (e.g., scheduling, synchronization), their implementations in production operating system kernels, experimental studies of those implementations, and real-time application development. Pre: Graduate Standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ECE 5554:

Computer Vision

Techniques for automated analysis of images and videos. Image formation, feature detection, segmentation, multiple view geometry, recognition, and video processing. Pre: Graduate Standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s): null null

ECE 5560 (CS 5560):

Fundamentals of Info Security

Principles of information security and relevant mathematical concepts. Classical ciphers, relevant abstract algebra and number theory, symmetric-key ciphers, cipher modes of operation, and asymmetric-key ciphers. Cryptography and cryptosystems. Applications and standards relevant to network and computer security. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

ECE 5564:

Wearable and Ubiquitous Computing

Issues in the design and use of wearable and ubiquitous computing systems. Topics covered include current research issues in system-level low power design, input/output devices, location and context-awareness, and networking. Students are expected to design, implement, and evaluate a wearable computing device or application.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECE 4534 (UG) OR ECE 4550 (UG) OR ECE 4534 OR ECE 4550

Corequisite(s):

ECE 5565 (CS 5565):

Network Architecture and Protocols

5565: Principles and concepts of networking and protocols, with emphasis on data link, network, and transport protocols. Contemporary

provide insight into practical networks including the Internet. Quantitative and qualitative comparisons of network architectures and protocols.

5566: Performance evaluation, design, and management of networks.

Use of queuing and other analytical methods, simulation, and experimental methods to evaluate and design networks and protocols.

Network management architectures and protocols. Graduate standing in EE, ECE, CS, or IT is required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): STAT 4714 (UG) OR STAT 4714

Corequisite(s):

ECE 5566 (CS 5560):

Network Architecture and Protocols

5565: Principles and concepts of networking and protocols, with emphasis on data link, network, and transport protocols. Contemporary and emerging networks and protocols to illustrate concepts and to provide insight into practical networks including the Internet. Quantitative and qualitative comparisons of network architectures and protocols.

5566: Performance evaluation, design, and management of networks.

Use of queuing and other analytical methods, simulation, and experimental methods to evaluate and design networks and protocols.

Network management architectures and protocols. Graduate standing in EE, ECE, CS or IT is required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECE 5565 (UG) OR ECE 5565

Corequisite(s):

ECE 5574G:

ADV Software Development CAE

Computer-aided engineering software that address the hierarchy of engineering analysis, design, and decision evaluation is developed with state-of-the-art computer tools. Linear graph theory is applied to the modeling of physical networks. Operator overloading, dynamic polymorphism, graphical user interfaces, dynamic link libraries, and multiple threaded programs are considered. Pre-requisite: Graduate Standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ECE 5580:

Cryptographic Engineering

Implementation of cryptographic operations and protocols in contemporary computing platforms. Mapping of cryptographic operations, evaluation and optimization of performance and implementation cost, analysis of security against brute-force cryptanalysis and implementation-level attacks, security-testing procedures, and architectures to support a trusted computing base.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECE 5560 OR CS 5560

Corequisite(s):

ECE 5584 (CS 5584):

Network Security

Fundamentals of network security. Network security architecture, user and attacker perspective. Practical applications and security standards. Protocol design principles and their impact on computer and network security. Authentication systems. Email security. Firewalls and intrusion detection. Security for wireless systems.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECE 5560 OR CS 5560

Corequisite(s):

ECE 5585:

IT Security and Trust

5585: Fundamental Internet and computer security principles and applications; legal and privacy issues, risk analysis, attack techniques, intrusion detection concepts, basic computer forensics, and system and application security hardening techniques. 5586: Advanced security and trust concepts and implementation in wired and wireless computer networks and computer systems; malware defenses, impact of channel fragility, node mobility, cooperative functionality, and resource constraints on security and trust at the different layers of the Internet protocol stack. Pre: Graduate standing for 5585.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ECE 5586:

IT Security and Trust

5585: Fundamental Internet and computer security principles and applications; legal and privacy issues, risk analysis, attack techniques, intrusion detection concepts, basic computer forensics, and system and application security hardening techniques. 5586: Advanced security and trust concepts and implementation in wired and wireless computer networks and computer systems; malware defenses, impact of channel fragility, node mobility, cooperative functionality, and resource constraints on security and trust at the different layers of the Internet protocol stack. Pre: Graduate standing for 5585.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECE 5585

Corequisite(s):

ECE 5590 (CS 5590):

System and Software Security

Secure software design, memory and file system security, operating system security for various platforms. Program classification, anomaly detection, malware detection and analysis. Technical challenges and problems in securing operating systems and software. Classic and modern algorithms, models, principles, and tools for system and application software security. Actual security examples.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): CS 5560 OR ECE 5560

Corequisite(s):

ECE 5604:

Computer-Aided Design and Analysis of Communication Systems

Simulation techniques for communication systems operating in random environments. Simulation models for stochastic signals and system components including coders, decoders, modulators, non-linear amplifiers, bit and carrier synchronizers, equalizers and receivers. Techniques for modeling time-varying channels. Monte Carlo simulation, semi-analytic simulation and variance reduction techniques applied to the analysis, design and performance evaluation of communication systems. Programming experience required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): (ECE 4624 (UG), ECE 4634 (UG), STAT 4714 (UG))

OR (ECE 4624, ECE 4634, STAT 4714)

Corequisite(s): ECE 5605

ECE 5605 (BMES 5525):

Stochastic Signals and Systems

5605: Engineering applications of probability theory, random variables and random processes. Time and frequency response of linear systems to random inputs using both classical transform and modern state space techniques. 5606: Response of continuous and discrete time, linear and nonlinear systems to Gaussian and non-Gaussian random processes. Introduction to signal detection theory and optimal filtering (estimation) techniques.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): STAT 4714 (UG) OR STAT 4714

Corequisite(s):

ECE 5606:

Stochastic Signals and Systems

5605: Engineering applications of probability theory, random variables and random processes. Time and frequency response of linear systems to random inputs using both classical transform and modern state space techniques. 5606: Response of continuous and discrete time, linear and nonlinear systems to Gaussian and non-Gaussian random processes. Introduction to signal detection theory and optimal filtering (estimation) techniques.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECE 5605 (UG) OR ECE 5605

Corequisite(s):

ECE 5620:

Advanced DSP and Filter Design

Advanced analysis, design, and realization of digital filters. Efficient Discrete Fourier Transform algorithm implementations, finite wordlength arithmetic, fixed point implementation, limit cycles, noise shaping, decimation and interpolation, multi-rate digital filter design, Hilbert transformers, analytic signal generation, basic adaptive filtering.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): (ECE 4624 (UG), STAT 4714 (UG)) OR (ECE 4624, STAT 4714)

Corequisite(s):

ECE 5634:

Information Theory

Transmission of information over noisy channels. Measures of information and transmission channel capacity. Use of codes to improve the reliability of such transmission. Mathematical theory of information.

Transmission at rates above channel capacity. Includes linear codes, error detecting and correcting codes, Hamming codes.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): (STAT 4714 (UG), ECE 4634 (UG), ECE 5605 (UG)) OR (STAT 4714, ECE 4634, ECE 5604)

Corequisite(s):

ECE 5635:

Radar Systems Analysis and Design

5635: This graduate-level course is the first in a two-part sequence in radar analysis and design. It covers the theory and practice of radar systems used for detection, tracking and location of targets. Topics include measurement of range and velocity, pulse compression, design of radar transmitter, receivers and antennas. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECE 5605

Corequisite(s):

ECE 5636:

Radar Systems Analysis and Design

5636: This graduate-level course is the second in a two-part sequence in radar analysis and design. It covers signal processing techniques used in pulsed radar systems. Topics include signal modeling, matched filter, frequency-modulated pulse compression waveforms, pulse Doppler processing, the Neyman-Pearson detection theory, constant false-alarm rate detection, beamforming and space-time adaptive processing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECE 5635

Corequisite(s):

ECE 5644:

Game Theory for Communication Networks

Analysis and optimization of large-scale engineering systems and communication networks using game theory. Introduction to the basics of game theory and its two branches- noncooperative and cooperative games-with application to the design of emerging communication systems and networks. A comprehensive treatment of the basics of game theory and learning with communication networking examples drawn from various areas such as cellular networks, mobile ad hoc networks, and related fields. Pre: Graduate Standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

ECE 5654:

Digital Communications II: Advanced Theory and Analysis

Fundamentals of the theory, design, and analysis of modern digital communication systems. Representation of signal in digital form. Design and analysis of digital modulation formats and receivers using signal space techniques. Combining error correction techniques with digital modulation. Viterbi algorithm for maximum likelihood sequence estimation. Equalization and adaptive equalization. Fading channels and diversity techniques.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): (ECE 4634 (UG), ECE 5605 (UG)) OR (ECE 4634, ECE 5605)

Corequisite(s):

ECE 5660:

Spread Spectrum Communications

Major topics include: direct sequence and frequency hopping methods, synchronization, resistance to jamming, low probability of detection, spreading codes and their generation, system performance, RAKE receivers, Code Division Multiple Access, cellular CDMA applications, wireless LAN applications, as well as commercial and military applications.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): (ECE 4634 (UG), ECE 5605 (UG)) OR (ECE 4634, ECE 5605)

Corequisite(s):

ECE 5664:

Cellular Communication Systems

Fundamental theory, design tradeoffs and practical issues of high capacity wireless communications systems. Trunking, RF propagation, frequency reuse, and legacy and emerging radio communications systems, including Long Term Evolution (LTE) cellular networks.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECE 5605

Corequisite(s):

ECE 5665:

Telecommunications

5665: Basic concepts in electrical engineering. Waveforms, spectra bandwidth. Fourier series and transform. Decibels, SNR, BER. Analog and digital transmission and modulations. Wire and radio links, link budgets, SNR and BER. Pre: Graduate standing. 5666: Analog modulations, AM, FM. Digital Modulations, ASK, FSK, PSK, QAM. RRC filtering, digital transmissions. Multiplexing, multiple access. Error control, FEC, ARQ. Local area networks. Optical communication systems. Satellite communications, GPS.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ECE 5666:

Telecommunications

5665: Basic concepts in electrical engineering. Waveforms, spectra bandwidth. Fourier series and transform. Decibels, SNR, BER. Analog and digital transmissions and modulations. Wire and radio links, link budgets, SNR and BER. Pre: Graduate standing 5666: Analog modulations, AM, FM. Digital Modulations, FSK, PSK, QAM. RRC filtering, digital transmission. Multiplexing, multiple access. Error control, FEC, ARQ. Local area networks. Optical communication systems. Satellite communications, GPS.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECE 5665

Corequisite(s):

ECE 5674:

Software Radios: Modern Radio Engineering

An introduction to software radios, devices that can be programmed to work with a variety of different radios. The course will cover the following topics: software radio architectures, existing software radio efforts, a review of basic principles, an analysis of receiver operation.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): (ECE 4624 (UG), ECE 4634 (UG)) OR (ECE 4624, ECE 4634)

Corequisite(s):

ECE 5684:

Error Control Coding

Use of error control codes to improve the reliability of digital communication and storage systems in the presence of noise. Algebraic structure of codes over finite fields. Error detecting and correcting codes. Block codes and convolutional codes, including Reed Solomon codes, LDPC codes, and turbo codes. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ECE 5704 (ME 5704):

Robotics and Automation

Automation, mechatronics, robot technology, kinematics, dynamics, trajectory planning, and control of two-dimensional and spatial robots; robot programming; design and simulation of robotic devices. Laboratories associated with robot forward/inverse kinematics, task planning, velocity kinematics, force rendering, control, haptics, mobile robotics, mapping/localization, computer vision and path planning. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 2

Instruction Type(s): Lecture, Online Lecture

350 Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

ECE 5714:

Robust Estimation and Filtering

An introduction to the analysis and design of maximum likelihood and robust estimators and filters. Maximum likelihood estimation theory: consistency, asymptotic efficiency, sufficiency. Robust estimation theory: qualitative robustness, breakdown point, influence function, change-of-variance function. Robust estimators: M-estimators, generalized M-estimators, high-breakdown estimators. Robust estimation of ARIMA models; Robust Kalman filter. Long memory processes: Hurst parameter estimation; parameter estimation of fractional ARIMA models. Applications to image and speech processing, communications, radar systems, and electric power systems.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECE 5605

Corequisite(s):

ECE 5734 (AOE 5734) (ME 5584):

Convex Optimization

Recognizing and solving convex optimization problems. Convex sets, functions, and optimization problems. Least-squares, linear, and quadratic optimization. Geometric and semidefinite programming. Vector optimization. Duality theory. Convex relaxations. Approximation, fitting, and statistical estimation. Geometric problems. Control and trajectory planning. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ECE 5744 (AOE 5744) (ME 5544):

Linear Systems Theory

Advanced introduction to the theory of time-varying and time-invariant linear systems represented by state equations; solutions of linear systems, uniform stability and other stability criteria, uniform observability and controllability, state feedback and observers.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECE 4405 OR ECE 4405 (UG) OR ECE 4624 (UG) OR ECE 4624 OR ECE 4634 (UG) OR ECE 4634 OR ME 4504 (UG) OR ME 4504 OR AOE 4004 (UG) OR AOE 4004

Corequisite(s):

ECE 5754 (AOE 5754) (ME 5554):

Applied Linear Systems

Develop an applied understanding of state-space representations for linear time invariant multi-input multi-output dynamic systems in both time domain and frequency domain. Introduction to modern state-space control methods; state feedback and output feedback. Realistic design problems with numerical simulations of practical implementations.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECE 4405 OR ECE 4624 OR ECE 4634 OR ME 4504 OR AOE 4004 OR ECE 4405 (UG) OR ECE 4624 (UG) OR ECE 4634 (UG) OR ME 4504 (UG) OR AOE 4004 (UG)

Corequisite(s):

ECE 5764 (AOE 5764) (ME 5564):

Applied Linear Control

Analysis and design of sampled-data systems, extraction of discrete-time dynamic models from experimental data, and implementation of dynamic compensators on digital processors. In-depth design experience with LQR optimal control and an introduction to Kalman filtering. Realistic design problems with numerical simulations of practical implementations.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECE 5744 OR ECE 5754 OR ME 5554 OR ME 5544 OR AOE 5744 OR AOE 5754

Corequisite(s):

ECE 5774 (AOE 5774) (ME 5574):

Nonlinear Systems Theory

Introduction to the theory of systems of coupled, nonlinear, time-varying ordinary differential equations: existence and uniqueness of solutions; continuous dependence on parameters; stability of equilibria and stability analysis techniques; input-to-state stability; input-output stability; nonlinear design techniques including input-state and input-output feedback linearization, backstepping, and sliding mode control.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECE 4405 (UG) OR ECE 4405 OR ECE 4624 (UG) OR ECE 4624 OR ECE 4634 (UG) OR ECE 4634 OR ME 4504 (UG) OR ME 4504 OR AOE 4004 (UG) OR AOE 4004

Corequisite(s):

ECE 5805:

Graduate Design Project and Report

Industry-like two semester, team-based design experience. Design and implement solutions to meet multiple realistic constraints; design to incorporate appropriate engineering standards. A specific, complex engineering design problem taken from problem definition to product realization and testing. Written and oral communication, professional development, project management, and working within a team. 5805: Determine and formulate an engineering problem with multiple realistic constraints. Generate and select design alternatives. Apply design and analysis methods to develop, evaluate, and communicate a detailed project design. 5806: Implement and refine the project design from ECE 5805. Test, analyze, document, and deliver the resulting project outcomes. A final oral and written examination that satisfies the Master of Engineering (MEng) program requirements. Pre: Graduate standing in Electrical Engineering and Computer Engineering Master of Engineering degree students only for 5805; 5805 (B) for 5806.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ECE 5806:

Graduate Design Project and Report

Industry-like two semester, team-based design experience. Design and implement solutions to meet multiple realistic constraints; design to incorporate appropriate engineering standards. A specific, complex engineering design problem taken from problem definition to product realization and testing. Written and oral communication, professional development, project management, and working within a team. 5805: Determine and formulate an engineering problem with multiple realistic constraints. Generate and select design alternatives. Apply design and analysis methods to develop, evaluate, and communicate a detailed project design. 5806: Implement and refine the project design from ECE 5805. Test, analyze, document, and deliver the resulting project outcomes. A final oral and written examination that satisfies the Master of Engineering (MEng) program requirements. Pre: Graduate standing in Electrical Engineering and Computer Engineering Master of Engineering

degree students only for 5805; 5805 (B) for 5806.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECE 5805

Corequisite(s):

ECE 5894:

Final Examination

NONE

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ECE 5904:

Project and Report

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research, Online Research

Instruction Type(s): Research, Online Research

Prerequisite(s):

Corequisite(s):

ECE 5914:

Autonomous Systems Seminar

Weekly technical presentations from local and visiting scholars on current topics related to the theory, design and development, and application of autonomous vehicle systems. Pre-requisite: Graduate Standing required

Credit Hour(s): 1

Lecture Hour(s): 1

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ECE 5944:

Seminar

To acquaint graduate students with recent and current research results and trends and to introduce researchers to students performing important work in Electrical and Computer Engineering.

352 Credit Hour(s): 1

Lecture Hour(s): 1

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ECE 5964:

Field Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ECE 5974:

Independent Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Independent Study, VI

Instruction Type(s): Independent Study, VI

Prerequisite(s):

Corequisite(s):

ECE 5984:

Special Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ECE 5994:

Research and Thesis

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research, Online Research

Instruction Type(s): Research, Online Research

Prerequisite(s):

Corequisite(s):

ECE 6104:

Advanced Topics in Electromagnetics

Advanced topics of current interest in Electromagnetic Engineering.

Topics are selected from current technical literature. May be repeated for credit.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECE 5105

Corequisite(s):

ECE 6114:

Advanced Analytical Electromagnetics

This course comprises PhD-level material covering exact and asymptotic analytical techniques for the solution of advanced electromagnetic problems involving wave propagation and scattering by finite and extended media inhomogeneities.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECE 5106 (UG) OR ECE 5106

Corequisite(s):

ECE 6115:

Antenna Theory and Design I,II

6115: Antenna systems and arrays: antennas in systems, antenna synthesis array fundamentals, array excitation and mutual impedance, waveguide slot arrays, microstrip antennas, microstrip elements, microstrip planar and conformal arrays, numerical methods for antenna analysis, Method of Moments and FDTD, antenna measurements, phased arrays. 6116: Reflectors and aperture antennas: aperture theory, analytical and computer-based designs, reflector antenna fundamentals, numerical methods for reflector analysis, general formulation of GO, PO, GTD, PTD and UTD methods, Gaussian beams, reflector optic configurations, prime-symmetric, Gregorian, Cassegrain and prime-offset reflector systems, analysis of strut scattering, aperture blockage, spillover, G/T analysis, measuring and commissioning reflector systems, reflector feed array, focal plane arrays, defocused arrays.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECE 5105

Corequisite(s): null null

ECE 6116:**Antenna Theory and Design I,II**

6115: Antenna systems and arrays: antennas in systems, antenna synthesis, array fundamentals, array excitation and mutual impedance, waveguide slot arrays, microstrip antennas, microstrip elements, microstrip planar and conformal arrays, numerical methods for antenna analysis, Method of Moments and FDTD, antenna measurements, phased arrays. 6116: Reflectors and aperture antennas: aperture theory, analytical and computer-based designs, reflector antenna fundamentals, numerical methods for reflector analysis, general formulation of GO, PO, GTD, PTD and UTD methods, Gaussian beams, reflector optic configurations, prime-symmetric, Gregorian, Cassegrain and prime-offset reflector systems, analysis of strut scattering, aperture blockage, spillover, G/T analysis, measuring and commissioning reflector systems, reflector feed array, focal plane arrays, defocused arrays.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECE 5105

Corequisite(s): null null

ECE 6124:**Advanced Numerical Electromagnetics**

A thorough coverage of numerical methods for electromagnetics, including topics on the foundations of function theory, Greens functions, mode-matching, and numerical expansion techniques in both the time and frequency domains. Emphasis will be placed on the method of moments and the finite element method, with development of the theoretical foundations of these methods. Alternate year course.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECE 5106 (UG) OR ECE 5106

Corequisite(s):

ECE 6154:**Photonic Devices and Systems**

Electromagnetic analysis of guided-wave optical devices and systems, including transmission properties of optical fibers, photonic crystal waveguides, grating structures, and coupled-wave components; soliton propagation in fibers; Erbium-doped and Raman fiber amplifiers; semiconductor light sources and photodetectors; wavelength-division multiplexed systems.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECE 5105

Corequisite(s):

ECE 6174 (AOE 6174):**Computational Plasma Dynamics**

Computational techniques for investigating processes in plasmas over a broad range of spatial and temporal scales. Investigation of physical processes including electrodynamics, waves and turbulence, space propulsion, spacecraft environmental effects and various laboratory applications. Computational techniques including full Particle-in-Cell (PIC), hybrid (fluid-electron, PIC ion), magnetohydrodynamics MHD and two-fluid methods.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECE 5174 OR AOE 5174

Corequisite(s):

ECE 6204:**Advanced Topics in Electronics**

Advanced topics of current interest in electronics engineering, with particular emphasis on microelectronics. Topics are selected from current technical literature to stress and reflect important potential areas in the electronic field. These topics include multichip modules, electronic packaging, microwave packaging, modeling simulation and evaluation of high speed devices, wideband characterization of electronic materials and multilayer structures, time and frequency domain measurement techniques.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ECE 6214:**Optoelectronic Devices**

Principles of light generation and detection, operation, and design of state-of-the art optoelectronic and photonic devices. Advanced treatment of the operating principles of semiconductor optoelectronic devices with direct comparison to experimental data reported in the literature.

Credit Hour(s): 3

Lecture Hour(s): 3

354 Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECE 5200

Corequisite(s):

ECE 6304:

Advanced Topics in Power

Advanced topics of current interest in Electric Power Engineering. Topics are selected from current technical literature. Certain topics may be repeated.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ECE 6314:

Advanced Instrumentation in Power Systems

Role of advanced instrumentation in monitoring, control and protection applications in power systems. Effects and limitations of instrument transformers, signal conditioning circuits, analog to digital (A/D) converters and Digital Signal Processing (DSP) chips, time synchronization and sampling, output circuits and devices, and communication channels. Fast Fourier Transform (FFT), protection algorithms, phasor and frequency measurements.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECE 5314

Corequisite(s):

ECE 6334:

Computational Methods in Power Engineering

This course is designed to introduce various linear and nonlinear program based optimization algorithms that are specially suited for the design, analysis and operation of electric power systems, power processing devices, machines, and transformers.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECE 5324 (UG) OR ECE 5324

Corequisite(s):

ECE 6354:

Power System Dynamics and Control

Dynamic modeling, stability analysis, and control of multi-machine power systems. Single-machine dynamic modeling, multi-machine dynamic modeling, network differential-algebraic equations and solution methods, small-signal stability analysis, and design of power system stabilizers.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECE 5314

Corequisite(s):

ECE 6424:

PGMs and Structured Prediction

Advanced concepts in machine learning. Probabilistic graphical models and structured output prediction. Directed models (Bayes Nets), undirected models (Markov/Conditional Random Fields), exact inference (junction tree), approximate inference (belief propagation, dual decomposition), parameter learning (MLE, MAP, EM, max-margin), structure learning.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECE 5424G OR CS 5824

Corequisite(s):

ECE 6504:

Advanced Topics in Computer Engineering

Advanced topics of current interest in computer engineering which are taken from current research topics and/or technical publications.

Prerequisites at 5000 level dependent on specific topics.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ECE 6524 (CS 6524):

Deep Learning

Advanced concepts in Machine Learning and Deep Learning. Models (multi-layer perceptrons, convolutional neural networks, memory networks), learning algorithms (backpropagation, stochastic sub-gradient descent, dropout), connections to structured predictions (Boltzmann machines, unrolled belief propagation), and applications to perception and Artificial Intelligence (AI) problems (image classification, detection, and segmentation; image captioning; visual question answering;

automatic game playing).

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECE 5424G OR CS 5824

Corequisite(s):

ECE 6554:

Advanced Computer Vision

Current and state-of-the-art trends in computer vision, particularly in object recognition and scene understanding. Application of approaches in computer vision to various automatic perception problems. Strengths and weaknesses of computer vision techniques. Open questions and future research directions. Pre: 5554.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECE 5554

Corequisite(s):

ECE 6564 (CS 5584):

Multimedia Networking

This course examines and explores recent advances in multimedia networking technologies. Major topics include multimedia compression and standards, quality of service (QoS) support mechanisms and protocols, performance analysis, network calculus, IP multicasting, Internet multimedia applications, and multimedia transport over wireless networks.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECE 5565 (UG) OR ECE 5565

Corequisite(s):

ECE 6570:

Advanced Foundations of Networking

This course covers theoretical foundations that are necessary for advanced study of networking. It focuses on algorithm design and optimization techniques that are most commonly used to solve complex networking problems. Major topics include complexity analysis with applications to networking problems, design and proof of approximation algorithms, design of meta-heuristic algorithms, formulation techniques for network optimization, linear and non-linear optimization techniques with applications to networking, design of distributed algorithms with

proof of convergence for networks systems.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECE 5565 (UG) OR CS 5565 (UG) OR ECE 5565 OR CS 5565

Corequisite(s):

ECE 6604:

Advanced Topics in Communications

Advanced topics of current interest in communications, which are taken from publications and industrial information.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECE 5654 OR ECE 5655

Corequisite(s):

ECE 6634:

Multi-Channel Communications

In-depth study of modern multi-channel communications techniques, primarily multi-antenna systems (known as multiple input multiple output or MIMO) and Orthogonal Frequency Division Multiplexing (OFDM). Specifically the course examines multi-antenna techniques such as transmit and receive diversity, beamforming (including eigen-beamforming), and spatial multiplexing. Within the area of OFDM we examine modulation/demodulation, carrier bit loading, mitigating multipath, frequency-domain equalization, peak to average power reduction, and frequency offset mitigation. As time permits we will also investigate a third multi-channel technique known as multi-user scheduling or packet access networks.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECE 5605, ECE 5654

Corequisite(s):

ECE 6744 (AOE 6744) (ME 6544):

Linear Control Theory

Advanced introduction to the theory of optimal control of time-varying and time-invariant linear systems; Solutions to the linear-quadratic regulator, optimal filtering, and linear-quadratic-gaussian problems; Robustness analysis and techniques to enhance robustness of

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECE 5744 OR ECE 5754 OR ME 5544 OR ME 5554
OR AOE 5744 OR AOE 5754

Corequisite(s):

ECE 6774 (ISE 6574) (AOE 6774) (ME 6574):

Adaptive Control Systems

Introduction to the theory and methodology used to design adaptive controllers for uncertain systems, addressing issue such as input constraints, disturbance rejection, partial measurements, and robustness.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): (ECE 5774, ECE 5744) OR (ME 5544, ME 5574) OR
(AOE 5774, AOE 5744)

Corequisite(s):

ECE 6984:

Special Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ECE 7994:

Research and Dissertation

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research, Online Research

Instruction Type(s): Research, Online Research

Prerequisite(s):

Corequisite(s):

ENGINEERING EDUCATION

Jennifer Case, Head

Emeriti Faculty: Richard Goff;

Professors: Jennifer Case; Vinod Lohani; Holly Matusovich; Elizabeth McNair; Marie Paretti; Bevelee Watford;

Associate Professors: Jacob Grohs; David Knight; Walter Lee;

Assistant Professors: Diana Bairaktarova; Andrew Katz; Jeremi London; Homero Murzi Escobar; Nicole Pitterson;

Affiliated Faculty: Catherine Amelink; Liesl Baum Walker; Brenda Brand; Gary Downey; Thomas Martin; Alejandro Salado Diez; Earl Shealy; Lee Vinsel; Christopher Williams; Matthew Wisnioski;

Graduate Contact: knott@vt.edu

Graduate Site: <http://enge.vt.edu/graduateprogram.html>

Graduate Student Manual: https://enge.vt.edu/content/dam/enge_vt_edu/graduateprogram/ENGE%20Graduate%20Manual%202019-20.pdf

The Engineering Education (ENGE) graduate program at Virginia Tech is ideal for students who are interested in becoming leaders in innovation and catalysts for change in society through rigorous research in the field of engineering education. The program strives to prepare students who are interested in a variety of professional goals, including engineering faculty positions in universities of all types, students who wish to pursue careers in policy, and students with a strong interest in educational research, corporate training management, university assessment or university administration. The cross-disciplinary PhD program is designed specifically to prepare graduates for careers across the entire range of engineering education. The inherent flexibility of the program allows students to tailor their curriculum and research to prepare them to achieve their goals in engineering education. In addition to the PhD, the Virginia Tech Department of Engineering Education also offers a 12-credit Graduate Certificate. The ENGE Graduate Certificate course offerings overlap significantly with those of the Engineering Education PhD and the Graduate School's Professoriate Certificate. Our Mission: Preparing scholars to advance knowledge and address significant challenges facing engineering education.

SPECIAL FACILITIES

The Department of Engineering Education has cultivated core research strengths in professional skills such as interdisciplinary, communication, collaboration, design education, motivation, global issues, and first year courses (particularly learning technologies). Retention, diversity, and assessment are important foundational concepts in the field of engineering education; as such, they are elements of all our projects.

(EC)3 Lab

The (EC)3 Lab is directed by Dr. Jacob Grohs. His team of students and faculty are committed to research, teaching, and outreach within three interconnected areas: Embracing Complexities: We love wicked problems, coupled systems, socio-ethical complexities, and trying to make sense of all sorts of messy data. Enacting Change: We are motivated by pressing challenges within the education system and broader society and we strive for positive change. this means we must sometimes work hands-on with stakeholders to achieve what we envision. Engaging Communities: We believe good things can happen

when diverse stakeholders come together around shared goals. We think often about our responsibility to others outside of our field and academia and we aim to be willing and committed partners.

ACE(D) Lab

Through real-world engineering applications, the Abilities, Creativity, and Ethics in Design, ACE(D), Lab experiential learning research crosses disciplines including engineering, psychology and the learning sciences, as we uncover how individual performance is influenced by abilities, personal interests and direct manipulation of physical and virtual objects. Led by Dr. Diana Bairaktarova, the ACE(D) Lab at Virginia Tech is dedicated to engineering and design education research and the engineering learner. Our interdisciplinary research focuses on the following three lines of inquiry: Using innovative technologies to study novel user interfaces, virtual and augmented learning and working environments that encompass human aspects at the cognitive, eye-tracking and sensory-motor levels. Investigating the role of individual aptitudes and abilities in performing and learning engineering through psychometric instruments and psychological interventions. Adopting design thinking as a philosophy (inspiration, ideation, and quick prototyping) to investigate user-centered design, empathic design and design for social innovation.

ASPECTS Research Group

The Academic Study of Pathways to Engineering for Children, Teachers, and Schools (ASPECTS) lab is led by Dr. Ken Reid. The group seeks to research and promote pre-college engineering education. Realizing that skill development and motivations for engineering are found far earlier than the admissions cycle for college, we seek pathways to knowledge about how students may learn, how teachers may instruct, and how school systems may implement engineering in PK-12. Our studies emphasize similar dimensions of education as college-based studies, with emphasis on enhancing the research community's understanding of the pre-college educational infrastructure and process so that we may better prepare students that enter college programs and alleviate concerns of ability and performance that are often found at the first-year level of college instruction. We also investigate developments in the first year of college to assess said concerns. Our contributions are also directed towards the introduction of engineering education as a means of augmenting teaching efforts and learning outcomes in other core subjects and state-of-the-art educational initiatives in K-12. We are focusing on engineering in K-12 and the first year of college.

Critical Frontiers Research Group

The Critical Frontiers Research Group comprises a group of students who are engaged with Dr. Jenni Case on their research journeys. Some are advised by her, some have her on their committee, some are working with her as graduate assistants, and others just choose to connect in the weekly Research Group meetings. We chose the title 'Critical Frontiers' to represent their research interests as each of them is

seeking in some way to push the boundaries in engineering education or higher education research. Many of us are interested in comparative educational questions; most of us are interested in culture and its relation to engineering education. We are open to critical approaches and we are interested in the sociology of education.

DEEP Lab

The VT DEEP Lab—Data Enhanced Educational Practice—is directed by Dr. David Knight. This lab is comprised of a collaborative team of researchers who work in interdisciplinary ways across the university. Spanning the “grade school-to-graduate school” continuum, our work tends to be at the macro-scale, and we investigate multiple aspects of the system (i.e., curriculum, co-curriculum, and organizational contexts) to understand how to help students achieve a variety of outcomes. Three themes characterize our research: Investigate organizational contexts, educational environments, and student experiences that support the development of diverse engineers who can become interdisciplinary problem-solving leaders across global contexts. Identify mechanisms to enhance existing organizational decision-making processes through the incorporation of local data. Leverage existing, large-scale data sets or collect new data in innovative ways to create intelligent feedback loops by connecting data, processes, and outcomes. Using these broad areas of focus as a guide, our research works toward improving the efficiency, effectiveness, and inclusiveness of the engineering and STEM education system.

ECLIPS Lab

The Engineering Competencies, Learning, and Inclusive Practices for Success (ECLIPS) Lab, is directed by Dr. Homero Murzi. This group focuses on understanding how to create contemporary, inclusive, data-driven pedagogical practices to develop effective learning environments that better support engineering students, especially those from traditionally marginalized populations (e.g., Latinx, Native American, International students) and to prepare them for the complexities of the engineering workforce. This diverse community critically explores issues in engineering education and higher education, focusing on the following areas: Competencies, Learning, and Inclusive Practices. They value international perspectives and seek to expand their research agenda in ways that include international collaborators.

ELITE Research Group

The Education, Learning, Identity and Transfer in Engineering Research Group (ELITE)- directed by Dr. Nicole Pitterson, engages in research aimed at creating, supporting and sustaining engineering learning environments, formal and informal, that are designed to provide students with relevant knowledge, skills and attitudes necessary to be successful in their course of study and future professions. Our research seeks to answer the following core questions: How do we assess learning formally and informally in engineering (STEM)? How we design and innovate learning environments? How we support the development of

students' identity and sense of belonging in engineering? What mechanisms can be best leveraged to optimize transfer of learning? How do we use instructional practices to foster cognitive engagement and conceptual understanding?

GUIDE Research Group

The GUIDE Research Group is a unique and collaborative effort between engineering education researchers and student-support practitioners, directly bridging the research-to-practice cycle. Members of GUIDE (1) conduct practice-informed research, focused on identifying areas of opportunity within engineering education to advance inclusion and diversity; and (2) develop and evaluate research-based solutions for making engineering a more inclusive and diverse environment. Our vision of a more inclusive engineering community—locally, nationally, and globally—inspires our quest to answer the following questions: How might we better support a diverse population of students? How might we make engineering more equitable, accessible, and inclusive? How might we broaden participation in engineering? How might we educate engineering students and faculty about diversity? Dr. Walter Lee, Director

IDEAS Lab

The Improving Decisions in Engineering Education Agents and Systems (IDEAS) lab is led by Dr. Andrew Katz. We use multi-modal data to understand and improve decisions made throughout engineering education systems. Our work is driven by one overarching question: how can we use extant and novel data to support decisions from the individual level up through the organizational level in order to achieve better societal outcomes through engineering education?

LabVIEW Enabled Watershed Assessment System Lab (LEWAS Lab)

The Learning Enhanced Watershed Assessment System (LEWAS) is a unique outdoor lab on Virginia Tech campus that integrates hardware and software components to monitor high frequency water (quality and quantity) and weather data from a site on Webb branch that flows through the campus. This lab has been integrated into various engineering courses at Virginia Tech and Virginia Western Community College and also supports research activities of graduate (PhD & MS) and undergraduate students. Currently, the lab hosts two projects funded by the National Science Foundation. Dr. Vinod Lohani, Director

RISE Research Group

The Research's Impact on Society and Education (RISE) Research Group is directed by Dr. Jeremi London. RISE is a diverse team of mixed methods researchers investigating the impact of research on society and education while simultaneously making an impact on STEM education through research.

SMILE Research Group

The Studies of Motivation and Identity in Learning Engineering (SMILE) group is directed by Dr. Holly Matusovich. This group engages in

research and outreach to all levels of learners from pre-kindergarten through academic and industry workforces. We aim to inform, support, and create learning environments that encourage and enable broad participation in engineering majors and careers. We use motivation-and-identity-related theories to examine ways to break down barriers, create opportunities, and engage all stakeholders (students, parents, teachers, co-workers) in thoughtful teaching and learning processes.

Virginia Tech Engineering Communications Center (VTECC)

VTECC integrates the professional and the technical to create a new kind of engineer. The Center brings faculty, students, and professionals together to explore, design, practice, and teach communication and collaboration in support of engineering work. Our lab provides a creative think space for engineering students and faculty to break through disciplinary molds and collaborate across boundaries to drive innovation.

Dr. Marie Paretti, Director

Wireless@vt.edu

The subgroup that Dr. Ken Reid is collaborating with works on the impact of serious games has on the teaching of wireless communication and the development and assessment of tutorials aimed to assist in the teaching and learning of spectrum sharing cognitive radios as well as hosting a Spectrum Sharing Competition each year. The work is facilitated by the CORNET radio network that is installed in Kelly Hall.

DEGREES OFFERED

PhD Degree

Offered In (Blacksburg)

TOEFL

Paper: (550.0)

Computer: (213.0)

iBT: (79.0)

PhD students must take a minimum of 90 total credits beyond the Bachelor's degree, submitted on a program of study subject to approval by the student's advisory committee. Curricular Requirements: Dissertation: 30 credits min. Engineering Education core courses: 8 credits Engineering Education Practicum: 3 credits (or special substitution) Engineering cognate: 12 credits Social Science cognate: 12 credits Electives: 12 credits Engineering Education Seminar: 4 credits ENGE & 1 credit GSSME Required Milestones and Examinations: Qualifying Examination Preliminary Examination PhD Research Proposal Progress Report Final Examination (Defense) Additional Information: At least 9 credits (ENGE or non-ENGE) will be at the 6000 level relevant to the student's research. At least 3 credits of Qualitative Research Methods and 3 credits of Quantitative Research Methods must be included among the cognate and elective classes. Up to 30 credits from a Master's degree may be counted toward the PhD at the discretion of the student's advisory committee. More detailed information regarding degree requirements is available in the Engineering Education Graduate Manual.

GRADUATE COURSES (ENGE)

ENGE 5024:

Design in Engineering Education and Practice

This course is focused on preparing future engineering faculty members and practitioners to teach engineering design as well as how to function more effectively in industry design environments. Material related to theories of student learning and appropriate pedagogical approaches to teaching an open-ended subject such as engineering design will be included. Student mentoring of design teams will be a key feature. Guest speakers from industry, academia, and government organizations will supplement the course work. Graduate standing in any department at Virginia Tech required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ENGE 5214:

Issues in Engineering Education

Current issues in Engineering Education (e.g., broadening participation, transformative practice, teaching and learning, emerging issues). Critical questions surrounding fundamental issues and approaches to engineering education research and practice. Pre: Graduate standing in College of Engineering.

Credit Hour(s): 2

Lecture Hour(s): 2

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ENGE 5224:

Disciplinary Literacy: Theorizing and Writing in Engineering Education

Communicating engineering education research via writing. Reading and synthesizing existing research. Common genres and rhetorical patterns in the field. Theory in engineering education research. Common paradigms and theoretical frameworks. Writing as a means to engage in theorizing. Effective writing and editing practices. Ethical responsibilities of writers. Pre: Graduate standing in College of Engineering.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ENGE 5304:

Graduate Student Success in Multicultural Environments

Socialization to the graduate student environment. Strategies for entering an effective mentee-mentor relationship. Virginia Tech's diversity and inclusion values. Focus on strategies for (1) facilitating clear communication with advisors, peers, or undergraduate mentees; (2) working within a culturally diverse environment; and (3) upholding ethical research practices. Pre: Graduate standing in the College of Engineering. Pass/Fail only.

Credit Hour(s): 1

Lecture Hour(s): 1

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ENGE 5404:

Assessment Techniques in Engineering Education

Assessment issues and skills important for engineering faculty or staff members at a college or university are addressed, including the strengths and weaknesses of a variety of quantitative and qualitative assessment strategies. Assessment is framed as an integrated part of course design, and ABET engineering accreditation criteria and procedures are discussed in-depth. Students will design and conduct an assessment in engineering course and learn important considerations in coordinating department or college resources in preparation for an ABET review.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ENGE 5014

Corequisite(s):

ENGE 5504:

Practicum in the Engineering Classroom

Preparation for and practical experience as a teacher in the engineering classroom. Student must have primary responsibility for a class, workshop, or laboratory. Design and presentation of plans, lectures, workshops, and laboratories in the engineering classroom. Discussion, review, and evaluation of performance by senior faculty and discussion with peer group. May be repeated. Graduate standing, and completion of

required.

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ENGE 5604:

Engineering Education Research Methods

This course introduces methods and considerations specific to research in engineering education. Quantitative, qualitative and mixed methods are discussed as well as measures of research quality. Students will learn to design and critique engineering education research quality.

Students will learn to design and critique engineering education research that addresses standards of rigor and quality. Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ENGE 5704:

Engineering Education Graduate Seminar

This course is designed to bring contemporary issues in engineering education research into the classroom. Experts from academia, industry, and the corporate world will be invited to make presentations on engineering education research issues including recruitment of minorities, retention issues, technology integration into engineering curricula, distance learning, engineering content into K-12 curriculum, learning theories, engineering education policy issues, etc. In addition, graduate school procedures relevant to various graduate programs in the EngE department will be explained. Altogether the course will include a minimum of 11 seminar presentations. Students will learn to critique engineering education research presentations and will demonstrate knowledge of contemporary issues in engineering education research. Graduate standing required.

Credit Hour(s): 1

Lecture Hour(s): 1

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ENGE 5714:

Topics in Engineering Education Research Methods

Topics in engineering education research methods. Explorations of current and emerging methods used in engineering education research. Adapting methods used in other fields for engineering education audiences. Implications for future research. May be repeated up to three times with different topics.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ENGE 5604

Corequisite(s):

ENGE 5974:

Independent Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Independent Study, VI

Instruction Type(s): Independent Study, VI

Prerequisite(s):

Corequisite(s):

ENGE 5984:

Special Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ENGE 5994:

Research and Thesis

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research, Online Research

Instruction Type(s): Research, Online Research

Prerequisite(s):

Corequisite(s):

ENGE 6714:

Topics in Engineering Education Research and Practice

Topics in engineering education. Explorations of current and emerging

practice. Historical and contemporary perspectives on current conversations within engineering education. Implications for research and practice. May be repeated up to three times with different topics.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ENGE 5014, ENGE 5604

Corequisite(s):

ENGE 6974:

Independent Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Independent Study, VI

Instruction Type(s): Independent Study, VI

Prerequisite(s):

Corequisite(s):

ENGE 6984:

Special Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ENGE 7994:

Research and Dissertation

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research, Online Research

Instruction Type(s): Research, Online Research

Prerequisite(s):

Corequisite(s):

ENGINEERING MECHANICS

Jennifer Wayne, Head

Emeriti Faculty: Norman Dowling; John Duke; John Grant; Zafer Gurdal;

Muhammad Hajj; Robert Heller; Scott Hendricks; Dr. Edmund Henneke; Robert

Jones; Luther Kraige; Ronald Kriz; Dean Mook; Kenneth Reifsnider; Mahendra Singh; Demetrios Telionis;

Professors: Romesh Batra; Rafael Davalos; Raffaella De Vita; David Dillard; Thomas Dingus; Stefan Duma; Hampton Gabler; Robert Gourdie; Steven McKnight; Saad Ragab; Thanassis Rikakis; John Socha; Mark Stremier; Pamela VandeVord;

Associate Professors: John Chappell; Zachary Doerzaph; Andrew Kemper; Stephen LaConte; Yong Lee; Jennifer Munson; Miguel Perez; Steven Poelzing; Robin Queen; Steven Rowson; Anne Staples; Surot Thangjitham; Costin Untaroiu; Scott Verbridge; Vincent Wang;

Assistant Professors: John Domann; Eli Vlasisavljevich;

Affiliated Faculty: Nicole Abaid; Alan Asbeck; Oumar Barry; Bahareh Behkam; Jonathan Black; Jonathan Boreyko; Scott Case; Hosein Foroutan; Tomonari Furukawa; Scott Huxtable; Sohan Kale; Rakesh Kapania; John Lesko; Roop Mahajan; Reza Mirzaeifar; Rolf Mueller; Michelle Olsen; Alexey Onufriev; Mayuresh Patil; Mark Paul; Shane Ross; David Schmale; Gary Seidel; Shima Shahab; Maryam Shakiba; Divya Srinivasan; Danesh Tafti; Saied Taheri; Pablo Tarazaga; Alexandrina Untaroiu; Craig Woolsey;

Clifton C. Garvin Professor & University Distinguished Professor:

Reynolds Metal Professor: Scott Case;

Adhesive & Sealant Science Professor: David Dillard;

J. Byron Maupin Professor: Muhammad Hajj;

L. Preston Wade Professor: Rafael Davalos;

Norris and Laura Mitchell Professor of Aerospace Engineering: Rakesh Kapania;

Harry C. Wyatt Professor, ICTAS Director: Stefan Duma;

Samuel Herrick Professor: Hampton Gabler;

N. Waldo Harrison Professor: Pamela VandeVord;

Newport News Shipbuilding Professor: Thomas Dingus;

Professor of Practice: Andre Muelenaer;

Graduate Contact: esmgradinfo@vt.edu

Graduate Site: <https://beam.vt.edu/graduate/mechanics.html>

The Engineering Mechanics (EM) program provides a strong foundation and sturdy framework for the discovery, development, transfer, and implementation of new knowledge in the areas of mechanics of materials and material systems, fluid mechanics, dynamics and vibration, biomechanics, and computational and experimental methods. The Department of Biomedical Engineering and Mechanics (BEAM), home to the EM program, is fully committed to providing an environment for strong undergraduate and graduate education that emphasizes fundamental understanding, high-quality teaching, frontier-level research, innovation, and service to the professional mechanics community. Instilling EM graduates with a highly flexible professional perspective enables them to pursue successful careers in a variety of engineering industries, in research environments, and in higher education. Indeed, EM graduates now populate prominent engineering departments across the nation and are transmitting the values of their engineering science training to new generations of students. Our graduates also serve as science and technology advisors to local,

regional, and federal governmental organizations; hold leadership positions in professional societies; and are active participants in public discourse on the role and value of engineering science in relation to the research and educational competitiveness of the Commonwealth of Virginia and our nation.

SPECIAL FACILITIES

The Engineering Mechanics graduate program has well-equipped research and teaching facilities on the Blacksburg campus for each of the supported research areas. Approximately 40,000 square feet of space supports program activities in Norris Hall, Kelly Hall, and several of the surrounding buildings.

Engineering Mechanics research groups

To view an up-to-date list all of faculty affiliated with the Engineering Mechanics program and their associated groups and facilities, visit <https://beam.vt.edu/graduate/mechanics.html>. Engineering Mechanics research groups include: Applied Interdisciplinary Research on Flow Systems (AIRFlowS) Lab: Hosein Foroutan, PI In the Applied Interdisciplinary Research on Flow Systems (AIRFlowS) Lab, we study a wide range of environmental, geophysical, and biological flow systems that are diverse in nature, scale, and physics. With a synergistic blend of numerical simulations, theory, experiments, and observations we characterize the transport of momentum, energy, and pollutants (chemicals, pathogens, allergens, and toxins) in these systems. Our research is highly interdisciplinary and integrates the knowledge of fluid dynamics, computational mechanics, atmospheric and environmental sciences, and aerosol sciences. The AIRFlowS Lab is led by Dr. Hosein Foroutan in the Department of Civil and Environmental Engineering. The Batra Group: Romesh Batra, PI The Batra Computational Mechanics Laboratory at Virginia Tech specializes in the development of mathematical and computational models of nonlinear and multi-physics phenomena that involve thermal, mechanical, viscous and electrical effects in elastic (e.g., rubber like, and biological materials), elastic-plastic (e.g., ceramics, metals, polymers), and thermo-visco-elasto-plastic materials under extreme loads such as those caused by improvised explosive devices and slamming of a boat into water (i.e., fluid-structure interaction). The group studies the initiation and progression of damage and failure in monolithic and composites including sandwich structures with fiber-reinforced face sheets and functionally graded materials/structures. Bioelectromechanical Systems Laboratory: Rafael Davalos, PI Bioelectromechanical Systems is a cross disciplinary field that combines engineering and science from the nano to the macro level. In our laboratory, we have developed technology for tissue viability detection, picoliter sample management, and imaging for molecular medicine. Using electrical feedback to perform complex procedures in biotechnology with precision and control, we have established robust methods for single cell analysis, selective cell concentration, and cancer therapy. Bio-Inspired Engineering Lab: Jake Socha, PI Our lab studies the biomechanics of motion in animals,

conducting integrative research that crosses traditional boundaries of engineering and biology. Currently, two broad themes of our research center around gliding flight in vertebrates and internal fluid flows in invertebrates. We aim to understand animal movements both for fundamental understanding of animal physiology, ecology and evolution, and as inspiration for novel engineering applications. Bioinspired Science and Technology Group: Rolf Mueller, PI Dr. Mueller's research group seeks to develop solutions for sensing in complex natural environments, e.g., to enable drones that are capable of autonomous navigation in complex natural environments. To achieve this, the flight and biosonar behavior of bats is studied in Borneo with high-speed camera and ultrasonic microphone arrays. The insights from the work are then used in the design of biomimetic soft-robots and matching deep learning paradigms to replicate the bats' abilities. Center for Advanced Automotive Research: Zachary Doerzaph, PI The Center for Advanced Automotive Research (CAAR) focuses on the research, development, and evaluation of next-generation automotive systems. This team strives to solve a broad set of challenges associated with integrating cutting-edge technologies into the vehicles of tomorrow. The primary research areas of CAAR include crash warning/avoidance/mitigation, connected vehicles, driver-vehicle interfaces, crash causation, and vehicle automation. Center for Data Reduction and Analysis Support: Miguel Perez, PI Dr. Perez is interested in a variety of efforts that help to improve the safety and convenience of our transportation systems. He currently leads a number of efforts related to naturalistic driving study design and analysis, data standardization, data preparation, data mining, and data analysis. In addition, Dr. Perez is involved in efforts to improve the response of emergency vehicles to motor vehicle crashes and to increase the usability of ride-sharing and automated vehicle technologies for individuals with disabilities. Complex Systems Laboratory: Nicole Abaid, PI The focus of the Complex Systems Laboratory is in the area of dynamical systems and control. Current research is largely focused collective behavior in multi-agent systems and spans agent-based modeling, studies of synchronization and consensus, field studies with wild animals, and bio-inspired robotic systems. Other research projects include studying the feasibility of auditory stimulation for closed-loop control of neural oscillations. Computational Biomechanics and Applied Mechanics (CBAM) Group: Costin D. Untaroiu, PI The Computational Biomechanics and Applied Mechanics (CBAM) Group conducts research on a large range of topics in applied mechanics, including injury biomechanics, human body modeling, vehicle safety, applied machine learning, and autonomous vehicles. This research is sponsored by industry consortiums (e.g. GHBM), and government agencies (e.g. NHTSA, NASA). Damage Science and Mechanics Laboratory: John "Jack" Duke, Jr., PI In order to assure the safety and reliability of critical assets, it is critical to understand the science of how systems degrade and how

this damage affects performance. The Damage Science and Mechanics Laboratory works within the multiple disciplines needed to achieve this goal. Sustainable system planning and design, life-extension, system prognostics, and system and structural health monitoring are areas where this work finds applications. The Dynamic Active Materials Laboratory: John Domann, PI The Dynamic Active Materials Laboratory investigates the coupling of solid mechanics and electrostatics in active material systems, including piezoelectric, magnetoelastic, and composite multiferroic structures. This work covers everything from creating analytical and numerical models to measuring fundamental material properties and developing devices that exploit the coupled behavior of these systems. Kevin P. Granata Biomechanics Lab: Robin Queen, PI The Kevin P. Granata Biomechanics Lab is the current center of research for Robin Queen, who is a fellow of the American College of Sports Medicine. She was previously the director of the "Coach K" Lab at Duke University where she worked with a variety of industry sponsors including the Nike Sport Research Lab and DonJoy Orthopedics. Her focus is on lower extremity biomechanics with an emphasis in foot and ankle biomechanics. Her work focuses on understanding changes in lower extremity loading and movement symmetry that result from injury and pathology. In addition, Dr. Queen works on development of various interventions to restore movement and loading symmetry in an attempt to decrease future risk of joint damage and prevent subsequent injuries. Laboratory for Fluid Dynamics in Nature: Anne Staples, PI The research at the Laboratory for Fluid Dynamics in Nature (FiNLab) is focused on two main themes: fluid flows in nature, and advanced computational methods for fluid flows. The natural systems studied at FiNLab range from insect respiratory flows, which occur at the microscale, to planetary atmospheric flows with length scales on the order of tens of kilometers. There is an emphasis on biomimetics for efficiency, resilience, and sustainability, on high performance computing, and on advanced multiscale computational modeling. Materials Response Group: Scott Case and David Dillard, PIs The Materials Response Group (MRG) is a research group within the Engineering Science & Mechanics Department at Virginia Tech focusing on the response of material systems to mechanical and environmental loading. Of particular interest are polymer and ceramic composites, adhesives, and scientific visualization. Multiphysics Intelligent and Dynamical Systems Lab: Shima Shahab, PI Multiphysics Intelligent and Dynamical Systems (MInDS) laboratory focuses on the intersection of smart materials and dynamical systems for various interdisciplinary applications such as energy harvesting, biomimetic locomotion and contactless acoustic energy transfer; biomedical opportunities and challenges. Current research topics at MInDS include intelligent fluid flow control using smart materials and metamaterial-inspired concepts, high-intensity focused ultrasound for wireless charging of low-power sensors, and ultrasound responsive drug delivery systems. The goal is

to design new generation of smart autonomous biomedical systems which leads to new medical diagnostics and treatments. Musculoskeletal Biomechanics Group: Jennifer S. Wayne, PI The Musculoskeletal Biomechanics group conducts research on a range of topics in biomechanics, particularly of the musculoskeletal system but also of biological tissues in general. Experimental analyses and computational simulations of function in normal, injured, and repaired states; CT image and morphometric analysis. Nature-Inspired Fluids & Interfaces Lab: Jonathan Boreyko, PI Inspired by nature's design for animals, plants, and the weather, our group's research involves characterizing unexplored phenomena and designing innovative materials and systems. Our research is a multi-disciplinary combination of fluids dynamics, heat transfer, interfacial phenomena, materials science, and renewable energy. Nonlinear Systems Laboratory: Craig Woolsey, PI The Nonlinear System Laboratory (NSL) in the Aerospace and Ocean Engineering Department at Virginia Tech provides a facility for research and instruction in dynamics and control of nonlinear systems, with particular focus on autonomous ocean and atmospheric vehicles. Founded in 2005, the NSL is co-directed by Dr. Cornel Sultan, Dr. Mazen Farhood, and Dr. Craig Woolsey. The Lab supports Virginia Tech's Autonomy and Robotics group. Ross Dynamics Lab: Shane Ross, PI The Ross Dynamics Lab performs mathematical modeling and experiments of nonlinear dynamics with applications to patterns of dispersal in oceanic and atmospheric flows, passive and active aerodynamic gliding, dynamic buckling of flexible structures, ship dynamics, orbital mechanics, and control of escaping dynamics. Dr. Ross is the Director and Recruiting Coordinator of BIOTRANS, an interdisciplinary graduate education program to cross-train graduate students in biology and engineering to work on biological transport problems in environmental and physiological systems. The STRETCH Lab: Raffaella De Vita, PI Research in the STRETCH Lab focuses on characterizing the mechanical properties of biological systems ranging from cellular components to tissues, with special emphasis on the development of new mathematical models and experimental methods. Although our research interests are diverse and continuously evolve over time, the common thread that runs through much of our work is our genuine passion in advancing fundamental and mechanistic knowledge of biological systems. This knowledge is crucial for the development of effective interventions to prevent and treat illness and disability. Theoretical and Applied Fluid Mechanics Group: Mark Stremmer, PI The Theoretical and Applied Fluid Mechanics (TAFM) Group conducts research on a range of topics in fluid mechanics, including reduced-order mathematical, numerical, and experimental models of fluid flows, with an emphasis on fluid-structure interaction, flows dominated by coherent vortical structures, microfluidic systems, fluid dynamics in biological systems, and connections to dynamical systems theory, particularly applications to fluid mixing.

DEGREES OFFERED

MS Degree

Offered In (Blacksburg)

TOEFL

Paper: (577.0)

Computer: (233.0)

iBT: (90.0)

MS thesis option Students pursuing the MS thesis degree option must complete at least 30 credit hours, including at least 21 graded course credit hours and satisfactorily prepare and defend a master's thesis. The final transcript will designate the degree as thesis. The MS thesis option must satisfy the following requirements: ESM 5014 Introduction to Continuum Mechanics (3 credits) One ESM 5xxx/6xxx course in two of the following three areas: dynamics, solid mechanics, or fluid mechanics (3 credits in each area, for a total of 6 credits) One course satisfying the mathematics requirement (3 credits) Graded elective courses (at least 9 credits) ESM 5994 Research and Thesis (at least 6 credits) MS students must also pass at least two credit hours of 5944 Seminar during two separate semesters. These seminar credits are not included on the Plan of Study. The MS Plan of Study may contain a combination of 5xxx and 6xxx-level courses and a maximum of six (6) hours of approved 4xxx-level courses. A minimum of 12 course credits must be labeled ESM (not including 5944 or 5994). A maximum of six (6) credit hours of independent study (IS) or special study (SS) courses can be used to complete the Plan of Study, with the total for both IS and SS courses not exceeding six (6) hours. MS non-thesis option Students pursuing the MS non thesis degree option must complete at least 30 graded course credit hours and satisfactorily pass a comprehensive oral examination. The final transcript will designate the degree as non thesis. The MS non-thesis option Plan of Study must include at least 30 credit hours that satisfy the following requirements: ESM 5014 Introduction to Continuum Mechanics (3 credits) Two ESM 5xxx/6xxx courses in two of the following areas: dynamics, solid mechanics, or fluid mechanics (3 credits in each area, for a total of 6 credits) One course satisfying the mathematics requirement (3 credits) Graded elective courses (at least 18 credits) MS students must also pass at least two credit hours of 5944 Seminar during two separate semesters. These seminar credits are not included on the Plan of Study. The MS Plan of Study may contain a combination of 5xxx and 6xxx-level courses and a maximum of six (6) hours of approved 4xxx-level courses. A minimum of 12 course credits must be labeled ESM (not including 5944 or 5994). A maximum of six (6) credit hours of independent study (IS) or special study (SS) courses can be used to complete the Plan of Study, with the total for both IS and SS courses not exceeding six (6) hours.

MEng Degree

Offered In (Blacksburg)

TOEFL

Paper: (577.0)

Computer: (233.0)

iBT: (90.0)

Master of Engineering (MEng) This program is oriented toward engineering practice instead of fundamental research, teaching or further

study. This degree is intended to increase the competence of students who are interested in design, development, operation, and engineering practice. Students pursuing the MEng degree option must complete at least 30 credit hours and satisfactorily prepare and defend an engineering project report. The purpose of the project report is to develop and demonstrate the candidate's ability to plan and execute projects relating to the practice of engineering. The MEng option Plan of Study must include at least 30 credit hours that satisfy the following requirements: ESM 5014 Introduction to Continuum Mechanics (3 credits) Two ESM 5xxx/6xxx courses in two of the following areas: dynamics, solid mechanics, or fluid mechanics (3 credits in each area, for a total of 6 credits) One course satisfying the mathematics requirement (3 credits) Graded elective courses (at least 15 credits) ESM 5904 Project and Report (3 credits) MEng students must also pass at least two credit hours of 5944 Seminar during two separate semesters. These seminar credits are not included on the Plan of Study. The MEng Plan of Study may contain a combination of 5xxx and 6xxx-level courses and a maximum of six (6) hours of approved 4xxx-level courses. A minimum of 12 course credits must be labeled ESM (not including 5944 or 5994). A maximum of six (6) credit hours of independent study (IS) or special study (SS) courses can be used to complete the Plan of Study, with the total for both IS and SS courses not exceeding six (6) hours.

PhD Degree

Offered In (Blacksburg)

TOEFL

Paper: (577.0)

Computer: (233.0)

iBT: (90.0)

Students must earn a minimum of 90 credit hours beyond the bachelor's degree. A Master's degree is not required for admission the program. Core Courses ESM 5014: Intro to Continuum Mechanics (3 credits) ESM 5314: Intermediate Dynamics (3 credits) ESM 5024: Intro to Solid Mechanics (3 credits) ESM 5054: Intro to Fluid Mechanics (3 credits) ESM 5004: Scientific Communication in Engineering Mechanics (2 credits) Math Courses MATH 5000-6000 level courses (3 credits). See EM Graduate Regulations manual for approved Math courses. ESM Courses Additional ESM coursework, ESM 5000-6000 level courses (6 credits). See EM Graduate Regulations manual for approved courses. Additional Coursework 5000-6000 level courses that support area of doctoral research (12 hours) Seminar ESM 5944 (Minimum of 4, one-credit hour seminars) (4 credits) Program-specific credits from above: 39 hours Additional Coursework Agreed upon by student and advisory committee: 21 hours Dissertation Research ESM 7994 (Research/Thesis) (30 hours) Minimum Total Credits: 90 PhD students must also pass at least four credit hours of 5944 Seminar during four separate semesters. These seminar credits are not included on the Plan of Study. The PhD Plan of Study may contain a combination of 5xxx and 6xxx-level courses and a maximum of six (6) hours of approved 4xxx-level courses. A minimum of 20 course credits must be labeled ESM (not including 5944 or 5994). A maximum of three (3) credit hours of independent study (IS) can be used to complete the Plan of Study.

GRADUATE COURSES (ESM)

ESM 5004:**Scientific Communication in Engineering Mechanics**

Strategies and techniques for effective scholarly and professional communication. Preparation for writing journal and conference papers, developing grant proposals. Critical analysis of the presentation of research articles and grant proposals. Designing and presenting conference talks and posters. Seminar presentations. Informal communication. Ethics in communication. Pre: Graduate Standing.

Credit Hour(s): 2

Lecture Hour(s): 2

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ESM 5014:**Introduction to Continuum Mechanics**

Analysis of stress and deformation at a point. Development of the basic equations of a continuous medium by applying the basic laws of conservation of mass, linear momentum, moment of momentum and those of thermodynamics. Study of constitutive axioms and constitutive relations for fluids and solids. Specialization of the field equations to simple boundary-value problems of solid mechanics and fluid mechanics with simple solutions.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ESM 3015

Corequisite(s):

ESM 5024:**Intro to Solid Mechanics**

Review of fundamental solid mechanics concepts including strain, stress. Nonlinear and linear elasticity, yield, elastic-plastic problems, flow plasticity, flow instabilities, viscoelasticity, viscoplasticity, creep, and fracture.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ESM 5044G:**Advanced Mechanics of Composite Materials**

Introduction to the deformation, stress, and strength analysis of

continuous-fiber-polymer-matrix laminated composites. Fabrication, micromechanics of stiffness and expansional coefficients, classical lamination theory. Environmentally induced stresses. Computerized implementation and design. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ESM 5054:**Introduction to Fluid Mechanics**

Fundamentals of fluid mechanics, including approximations, flow regimes, boundary conditions, vorticity, Bernoulli equations, boundary layers, lift, separation and drag, introduction to turbulence, waves in fluids.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ESM 5014

Corequisite(s):

ESM 5114:**Topics in Composite Mechanics**

In-depth study of a selected topic in analysis of composite materials, such as mechanics of composite strength and lifetime, mechanics of laminated composite structures, mechanics of discontinuous fiber composites. Includes 3D anisotropic constitutive behavior and stress analysis. May be repeated three times with different content for a maximum of 9 credits. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ESM 5044G

Corequisite(s):

ESM 5124:**Theory of Elasticity**

Equations of equilibrium, strain-displacement, compatibility, and constitutive equations in terms of Airy and complex potential stress functions applied to plane engineering boundary value problems including beams, disks, thick-walled tubes, perforated plates, and various stress raiser problems. Three-dimensional applications to torsion, bending, semi-infinite solids. Galerkin vector, Papkovich

functions.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ESM 5014, MATH 4426

Corequisite(s):

ESM 5134:

Advanced Mechanics of Materials

Thick-walled cylinders and spinning disks, introduction to thin plates and shells, beams on elastic foundations, energy methods, torsion of thin-walled members, unsymmetric bending, shear center, curved beams, beam-columns and ties, introduction to plastic collapse, introductory applied elasticity.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ESM 5144 (MSE 5144):

Deformation and Fracture of Materials

Deformation and fracture of engineering materials is considered in the context of solid mechanics and engineering methods for predicting strength and life. Topics include plasticity, failure criteria, fracture mechanics, crack growth, strain-based fatigue, and creep.

Microstructure-property relationships are discussed. Laboratory demonstrations of behavior in mechanical tests are included. Partially duplicates material in ESM 4024 and both should not be taken.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ESM 3054

Corequisite(s):

ESM 5174 (CHEM 5174):

Polymer Viscoelasticity

Constitutive models of linear viscoelastic materials, experimental aspects, polymer response to mechanical and electrical inputs, solid state NMR and microwave interactions with polymers, free volume theories, temperature and environmental effects on polymers, physical aging of glasses. Consent required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ESM 5224 (BMES 5124):

Advanced Musculoskeletal Biomechanics

Skeletal anatomy and mechanics. Muscle anatomy and mechanics.

Theory and application of electromyography. Motion and force measuring equipment and techniques. Inverse dynamics modeling of the human body. Current topics in musculoskeletal biomechanics research.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ESM 5245G:

Mechanics Animal Locomotion

The mechanical and biological principles of animal locomotion.

Comparative examples from locomotor modes including walking, running, jumping, climbing, burrowing, and crawling used to extract general principles underlying kinematics, dynamics, energetics, and control. Terrestrial locomotion-based bio-inspired design.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ESM 5246G:

Mechanics Animal Locomotion

The mechanical and biological principles of animal locomotion.

Locomotor modes including active and gliding flight, swimming, jetting, and running on water, examined from perspectives of kinematics, dynamics, energetics, and control. Engineering design inspired by fluids-based biological locomotion.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

Mechanics of Adhesive Bonding and Interfaces

Principles of mechanics applied to adhesively bonded joints and interfaces, overview of adhesion technology, stress analysis of adhesive joints, stresses in bimaterial systems and interfaces, failure mechanisms and fracture, thermodynamic and observed toughnesses, time dependence and durability, design.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

ESM 5304 (AOE 5034):

Mechanical and Structural Vibrations

Free and forced vibration of single-degree-of-freedom systems, multi-degree-of-freedom systems, continuous systems including strings, rods, bars, and beams. Natural frequencies and modes. Rigid Body modes. Proportional and nonproportional damping. Response to harmonic, periodic, and nonperiodic excitations. Solutions by modal analysis, direct integration and Fourier Series. Approximate methods including assumed modes and the Rayleigh-Ritz method. Advanced topics chosen by instructor.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ESM 5305 (BMES 5305):

Biomechanics of the Cardiovascular System

5305: Mechanics of the heart, arterial blood vessels and microcirculation; history of the circulation; anatomy and physiology of the heart; mechanics of cardiac contraction; cardiac fluid mechanics; work, energy, efficiency of cardiac function. 5306: Rheology of blood; hematology; elasticity of blood vessel walls; transport processes; control of the circulation; mathematical analysis of pulsatile blood flow and pulse-wave propagation through small arteries, capillary beds and extra-corporeal devices.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

ESM 5306:

Biomechanics of the Cardiovascular System

5305: Mechanics of the heart, arterial blood vessels and microcirculation; history of the circulation; anatomy and physiology of the heart; mechanics of cardiac contraction; cardiac fluid mechanics; work, energy, efficiency of cardiac function. 5306: Rheology of blood; hematology; elasticity of blood vessel walls; transport processes; control of the circulation; mathematical analysis of pulsatile blood flow and pulse-wave propagation through small arteries, capillary beds and extra-corporeal devices.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ESM 4106

Corequisite(s):

ESM 5314:

Intermediate Dynamics

Review of Newtonian mechanics, fundamental concepts of analytical mechanics, Hamilton's principle, Lagrange's equations, rigid-body dynamics, Euler's equations, gyroscopic principles, definitions of stability, geometric theory (phase-plane trajectories), limit cycles, state-space analysis, Routh-Hurwitz criterion, Liapunov direct method.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ESM 5334:

Interfacial Fluid Mechanics

Interfacial fluid systems involving surface tension, interfacial hydrodynamics, and phase-change heat transfer. Scaling analysis and non-dimensionalization will be used to model a variety of interfacial phenomena relevant to fluid mechanics and phase-change heat transfer. Capillarity, surface wettability, hydrodynamics of interfaces, flow instabilities, long range forces, convective and diffusive boundary layers, homogeneous and heterogeneous nucleation, and multiphase flows.

Pre: Graduating standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ESM 5344:**Wave Propagation in Solids**

Formulation and solution of propagation problems in infinite, isotropic media. Solution of the reflection-refraction problem at plane interfaces.

Discussion of Rayleigh, Love, and general surface waves. General treatment of wave propagation in infinite anisotropic media. Wave diffraction phenomena. Waves in bounded media: bars and plates.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ESM 5014

Corequisite(s):

ESM 5405:**Clinical Internship in Biomedical Engineering**

Off-campus student exposure and participation in a planned clinical experience for those preparing to enter the field of Biomedical Engineering. On-campus lecture/lab/demonstration sessions to supplement the clinical experience. Students are placed in selected hospitals throughout the local area during two summer sessions under close supervision of a university staff member and cooperating medical personnel.

Credit Hour(s): 3

Lecture Hour(s): 2

Instruction Type(s): Lab, Lecture, Online Lecture

Instruction Type(s): Lab, Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ESM 5406:**Clinical Internship in Biomedical Engineering**

Off-campus student exposure and participation in a planned clinical experience for those preparing to enter the field of Biomedical Engineering. On-campus lecture/lab/demonstration sessions to supplement the clinical experience. Students are placed in selected hospitals throughout the local area during two summer sessions under close supervision of a university staff member and cooperating medical personnel.

Credit Hour(s): 3

Lecture Hour(s): 2

Instruction Type(s): Lab, Lecture, Online Lecture

Instruction Type(s): Lab, Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ESM 5414:**Nonlinear Systems**

Dynamics of conservative and nonconservative systems; phase planes; local and global stability; damping mechanisms; self-excited oscillators.

Forced oscillations of one-degree-of-freedom systems; primary, secondary, and multiple resonances; period-multiplying bifurcations; strange attractors; chaos. Parametric excitations; Floquet theory; influence of damping and nonlinearity. Multi-degree-of-freedom systems; concepts of internal and external resonances; Hopf bifurcation.

Applications to continuous systems; strings, beams, plates, and shells.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ESM 5754, ESM 5304

Corequisite(s):

ESM 5454 (AOE 5054):**Elastic Stability**

Stability of elastic structural components under conservative loads; precise definitions of stability; energy approaches; Rayleigh-Ritz and Galerkin methods; and applications to column, arches, plates, and shells.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): CEE 3404 OR AOE 3124

Corequisite(s):

ESM 5504:**Introduction to Ideal Flow**

Kelvin-Helmholtz theory of vorticity. Velocity potential. Stream function. Complex potential and conformal mapping. Introduction to two-dimensional panel methods. Thin-airfoil theory. Steady and unsteady lifting flows.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ESM 5514:**Viscous Flow**

Governing equations of viscous heat-conducting gases. Exact solutions to the Navier-Stokes equations. Low- Reynolds-number flows.

Incompressible and compressible boundary layers. Finite-difference methods for boundary layers. Flow separation and strong viscous-inviscid interactions: interacting boundary layers and triple deck theory.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ESM 5014

Corequisite(s):

ESM 5524:

Compressible Flow I

Introduction to fundamentals of compressible fluid flow. Linearized theory, unsteady flows, steady flows, shock waves, wave interactions, method of characteristics.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ESM 5014

Corequisite(s):

ESM 5554 (CEE 5130):

Turbulence and Turbulent Flows

Nature and origin of turbulence, turbulent transport of momentum and heat, the dynamics of turbulence, statistical description of turbulence and spectral analysis. Examples of turbulent flows, boundary layers.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ESM 5734:

Introduction to the Finite Element Method

Formulation and computer implementation of finite element models of typical equations of fluid flow, heat transfer, and solid mechanics. The problems considered include heat conduction and convection, torsion, ground water flow, electrostatics and magnetism, plane elasticity, flow of viscous incompressible fluids, and plate bending. Both theoretical development and computer program development are studied. I

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ESM 5744:

Energy and Variational Methods in Applied Mechanics

Variational calculus, energy principles of solid mechanics, and variational methods of approximation applied to engineering problems. Derivation of equations of mechanics from energy and variational principles (i.e. virtual work principles). Formulation and solution of initial-, boundary- and eigen-value problems of engineering by direct variational methods, such as the Ritz, Galerkin, least-squares, and collocation methods.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): MATH 4425

Corequisite(s):

ESM 5754:

Introduction to Perturbation Methods

Asymptotic expansions and series, approximate solutions of algebraic equations, straightforward expansions and their regions of nonuniformities, the Lindstedt-Poincaré technique, the method of renormalization, the method of averaging, the method of matched asymptotic expansions.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): MATH 2214 OR MATH 2514 OR MATH 4544

Corequisite(s):

ESM 5894:

Final Examination

NONE

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ESM 5904:

Project and Report

NONE

Credit Hour(s): 1 TO 19

370 Lecture Hour(s):

Instruction Type(s): Research, Online Research

Instruction Type(s): Research, Online Research

Prerequisite(s):

Corequisite(s):

ESM 5944:

Seminar

Discussion of current research topics in Mechanics by local and visiting scholars. May be repeated with different content for a maximum of 4 credits. Pass/Fail only. Pre: Graduate Standing.

Credit Hour(s): 1

Lecture Hour(s): 1

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ESM 5974:

Independent Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Independent Study, VI

Instruction Type(s): Independent Study, VI

Prerequisite(s):

Corequisite(s):

ESM 5984:

Special Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ESM 5994:

Research and Thesis

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research, Online Research

Instruction Type(s): Research, Online Research

Prerequisite(s):

Corequisite(s):

ESM 6024:

Mechanics of Soft Tissues

Stress and strain tensors for large deformations, Conservation laws, Thermodynamics principles, Material symmetry, Hyperelastic materials, Chemoelasticity, Electroelasticity, Viscoelasticity, Initial and boundary conditions, Review of analytical and numerical methods for solving large deformation problems, Solutions of problems.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ESM 5014, ESM 5734

Corequisite(s):

ESM 6044:

Theory of Plates and Shells

Reduction of 3-D elasticity to an equivalent 2-D counterpart. Basic assumptions. Field equations of the theory of plates and shells. Linear and nonlinear theories. Buckling and vibrations. Postbuckling. Refined plate and shell theories. Implications of non-classical effects on the static, dynamic and buckling behaviors.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ESM 5014, (MATH 4425 OR MATH 4564)

Corequisite(s):

ESM 6054:

Fracture Mechanics

Linear elastic and elasto-plastic models of local stress fields around crack tips. Concepts of stress intensity strain energy release rate, strain energy density. Mathematical models for dynamic crack extension and fatigue crack growth. Correlation of mathematical models with fracture toughness testing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ESM 5014

Corequisite(s):

ESM 6254 (AOE 6254):

Turbulence Modeling and Simulation

In-depth study into the modeling and simulation of turbulent flows.

various approaches to turbulent closure. Turbulence modeling via algebraic, RANS, and Reynolds stress models. Turbulence simulation via DNS, LES and hybrid RANS/LES approaches and analysis of results. Turbulence compressibility effects, body forces, boundary conditions, wall functions, sub-grid modeling approaches, turbulence anisotropy and stress invariants, and realizability. Strengths and weaknesses of the different modeling and simulation approaches. Role of numerics in different modeling approaches. Pre: Graduating standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ESM 6314:

Advanced Dynamics

Fundamental concepts of analytical mechanics, variational principles, Lagrange's equations, rigid-body kinematics and dynamics, Euler parameters, quasi-coordinates, Euler's equations, gyroscopic systems, Hamilton-Jacobi equation, transformation theory, introduction to optimal control theory, advanced concepts in stability theory.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ESM 5314

Corequisite(s):

ESM 6514:

Computational Methods for Viscous Flows

Navier-Stokes equations in curvilinear systems. Thin-layer and parabolized Navier-Stokes equations. Stability analysis of finite-difference methods applied to model equations. Methods for grid generation. Finite-difference methods for compressible and incompressible Navier-Stokes equations. Spectral methods.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ESM 5514

Corequisite(s):

ESM 6714:

Applied Tensor Analysis

Basis vectors, Christoffel symbols, metric tensor. Covariant, contravariant vectors and tensors. Covariant differentiation. Orthonormal

systems and physical components of tensors. Surface tensors, curvature tensors, principal curvatures, geodesics and asymptotic lines. The basic ideas will be illustrated by and applied to problems in continuum mechanics, solid and fluid mechanics, rigid body dynamics, and electromagnetic theory.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): MATH 4574

Corequisite(s):

ESM 6734:

Finite Element Analysis

Alternative finite element models; three-dimensional problems; eigenvalue problems; nonlinear formulations for fluid flow and plate bending; and mathematical properties of finite-element approximations; direct and Newton-Raphson iterative methods for the solution of nonlinear equations; computer implementation of nonlinear finite-element models.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ESM 4734 OR ESM 5734

Corequisite(s):

ESM 6974:

Independent Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Independent Study, VI

Instruction Type(s): Independent Study, VI

Prerequisite(s):

Corequisite(s):

ESM 6984:

Special Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ESM 7994:**Research and Dissertation**

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research, Online Research

Instruction Type(s): Research, Online Research

Prerequisite(s):

Corequisite(s):

ENVIRONMENTAL ENGINEERING

Mark Widdowson, Head

Emeriti Faculty: Gregory Boardman; William Cox; David Kibler; John Novak;

Clifford Randall; Dusan Teodorovic;

Professors: Andrea Dietrich; Marc Edwards; Daniel Gallagher; Stanley Grant;

Jennifer Irish; William Knocke; John Little; Linsey Marr; Amy Pruden-Bagchi; Peter

Vikesland; Mark Widdowson;

Associate Professors: Erich Hester; Nina Stark; Kyle Strom;**Assistant Professors:** Hosein Foroutan; Gabriel Isaacman-VanWertz; Landon

Marston; Megan Rippey; Zhiwu Wang;

Research Associate Professors: Adil Godrej;**Charles P. Lundsford Professor:** Linsey Marr;**W. Thomas Rice Professor:** Amy Pruden-Bagchi;**Nick Prillaman Professor:** Peter Vikesland;**University Distinguished Professor:** Marc Edwards;**Charles E. Via, Jr. Professor:** John Little;**Assistant Professor of Practice:** Robert Scardina; Claire White; Kevin Young;**Research Assistant Professors:** Siddharth Saksena;**Graduate Contact:** shmartin@vt.edu**Extended Campus:** shmartin@vt.edu**Graduate Site:** <https://www.cee.vt.edu/prospective-graduate-students/>**Graduate Student Policy Manual:** <https://www.cee.vt.edu/wp-content/uploads/2018/07/Graduate-Policies-and-Procedures-Manual-Departmental.pdf>

The Environmental Engineering (ENE) Program of the Department of Civil and Environmental Engineering offers graduate study leading to the MS in environmental and water resources engineering and the PhD in civil engineering (with an environmental and water resources engineering emphasis). The program goals are to educate and prepare engineers for careers in the various fields of environmental engineering design, water supply management, site remediation, environmental modeling, pollution control engineering, water resources engineering, and public health protection. The MS in environmental engineering is open to students from all undergraduate engineering curricula or in a related field of science such as Biology, Chemistry, Mathematics, Soil

Science, Statistics or Geology. It is specifically designed to build upon undergraduate degrees in civil, biological systems, chemical, mechanical, and mining engineering. Within a few years of program completion, graduates of the ENE program should be able to combine skills gained through academic preparation and post-graduation experience so that they can: Exhibit technical competence through application of engineering knowledge problem-solving skills, and modern tools from multiple areas of environmental engineering practice in the analysis, evaluation, design, and construction of environmental engineering systems and system components. Apply skills of effective communication, teamwork, leadership, and professional and ethical behavior as complements to technical competence. Incorporate economic, environmental, social, and sustainability considerations into the practice of environmental engineering. Continue their technical and professional development, which may include professional licensure, graduate level education, continuing education courses, self-directed study, and participation in conference and committee activities. Please refer to the Civil and Environmental Engineering listing for more detailed information on the CEE Department, the academic "home" of the ENE program. (<http://www.cee.vt.edu/>).

SPECIAL FACILITIES

The ENE program offers a variety of labs space for students to conduct research as part of their degree program. The Kelso Baker Environmental Hydraulics Laboratory (BEHL) and the Occoquan Watershed Monitoring Laboratory (OWML) in Manassas, VA and the Potomac Aquifer Recharge Monitoring Laboratory (PARML) in Hampton, VA are among the labs available to students.

Computing Facilities

The Civil and Environmental Engineering Computer Lab (CEECL) is maintained as a state-of-the-art, collaborative learning environment. The instructional lab provides excellent multimedia equipment for faculty to demonstrate and instruct students in the use of computing tools through the Department's curriculum. Faculty and students also have access to a variety of supercomputing facilities and data visualization capabilities through the computer resources of Virginia Tech.

Experimental Facilities

The environmental engineering program occupies modern laboratories in Durham, Kelly, Steger, Patton and Hancock Halls. Laboratories and specialized experimental and analytical equipment support research programs related to areas such as water and wastewater treatment, hazardous and residuals waste management, water quality management, environmental chemistry, and air quality. Available equipment allows for the identification and quantification of most chemical and microbial environmental contaminants. The water resources engineering laboratories support basic and applied research activities in the areas of water, sediment, and pollutant movement in surface and groundwater sources. The Kelso Baker Environmental Hydraulics Laboratory houses two large (each 70 ft. long) tilting flumes, a medium length tilting flume, a 3-D laser Doppler velocimeter, a hot film anemometer, and numerous pieces of support instrumentation.

Occoquan Watershed Monitoring Laboratory (Manassas, Virginia)

373 The environmental engineering program also includes the Occoquan

Monitoring Laboratory (Manassas, Virginia), where research focuses on wastewater reuse, reservoir eutrophication control, and watershed monitoring and management. Web site: www.owml.vt.edu

Potomac Aquifer Recharge Monitoring Laboratory

The PARML, Hampton, is responsible for making determinations in a number of areas critical to the ongoing management of water quality in the Potomac aquifer, situated in the Hampton Roads area of Southeast Virginia. This work is in association with managed aquifer recharge associated with the \$1 billion SWIFT (Sustainable Water Initiative For Tomorrow) project.

DEGREES OFFERED

MS Degree

Offered In (Blacksburg, National Capital Region)

TOEFL

iBT: (90.0)

GRE

General: Verbal, Quantitative, Analytical

The purpose of the core curricula is to develop an understanding of the applicable chemical, physical, biological, and mathematical modeling fundamentals and then teach student how to apply these principles in a broad range of applied courses. Specialization can be in the traditional areas of air quality engineering, environmental modeling and simulation, environmental nanotechnology, hazardous waste management, water infrastructure, water resources engineering and water and wastewater process engineering. Emerging thrust areas include sustainable water supply and water reuse, water infrastructure and environmental nanotechnology. The MS ENE degree may be taken either as coursework only or with the permission of the faculty may incorporate a research thesis. The PhD program in Civil Engineering is designed to build upon the MS in environmental engineering, but also is open to students with master's degrees in other engineering disciplines. Areas of specialization are the same as for the MS degree, but the program of study are more individualized. See Departmental Manual at [:https://www.cee.vt.edu/wp-content/uploads/2019/07/Graduate-Policies-and-Procedures-Manual-Departmental.pdf](https://www.cee.vt.edu/wp-content/uploads/2019/07/Graduate-Policies-and-Procedures-Manual-Departmental.pdf)

GRADUATE COURSES (CEE)

CEE 5010:

Schedule Impact Analysis

Analysis of construction scheduling principles, scheduling specifications, contract administration, construction law, construction delay claims, and of accepted methodologies for performing schedule impact analysis of delaying events. Pre: Graduate Standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

CEE 5014:

Facility Delivery & Financing

Delivery and financing of constructed facilities with an emphasis upon civil infrastructure systems. Design of project delivery systems to encourage best value, innovation, and private sector participation. Public-private partnership strategies and factors that contribute to success or failure. Fundamentals of project feasibility, evaluation, and finance. Case studies of large-scale infrastructure projects. Pre-requisite:

Graduate Standing required

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CEE 5024:

Contract Administration and Claims Resolution

This course provides students with a knowledge of the different types of contracts used in civil engineering construction. Contracts are viewed as documents which assign responsibilities and allocate risks and emphasis is placed on contract administration as the first step in reducing costs and easing the burden of dispute resolution. Techniques for quantifying and resolving claims are studied.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CEE 5060:

Built Environment Information Modeling and Processing

Introduction to technologies that enable virtual modeling and processing of the infrastructure project life cycle. Introduction to theory and application of Building and Civil Information Modeling (BIM and CIM), and their integrated practices for the architectural, engineering and construction industries. Pre: Graduate Standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CEE 5074:**Global Virtual Design and Construction**

Fundamental aspects of modern civil engineering project execution in virtual workspaces. Participation in team-based virtual design and construction project involving students from other domestic and international universities. Design of organizational and task model, integration with design and cost models, identification of interventions that improve scheduling. Strengthened ability to work collaboratively with individuals from different countries/cultures. Both theory and practice emphasized. Pre: Graduate Standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CEE 5080:**Infrastructure Asset Management**

Comprehensive systems approach to civil infrastructure system and strategic-level asset management with emphasis on municipal, highway, building, dam, and bridge infrastructure. Course will cover various aspects of strategic-level infrastructure asset management: systems thinking, needs assessment, information technology and GIS data management, risk and reliability engineering, multi-criteria decision making process, infrastructure sustainability and resiliency, and renewal engineering (repair, rehabilitation, and replacement). Graduate Standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CEE 5084:**Information Technology for Infrastructure and Environment Systems**

With the acceleration of the process of global revolution in science, engineering and technology led by information technology, the human society is in a gradual transition from an industrial society into an information society. As a new productivity with the greatest potential at the present age, information technology has undergone great development. The incessant innovation in technology has also urged people to make better use of it and apply advanced information technology to their own industry. In recent years, Information Technology

(IT) and Cyber Infrastructure has been transforming engineering and business practices in many sectors, resulting in efficiency gains and improved services for the client. The infrastructure industry has been slow to utilize information technology effectively and slower still to grasp the ways in which the multitude of design, calculation, specification, project management, asset management, sensor technology, database and data analysis software applications relate to each other. This course provides an overview of the range of Information Technology (IT) applications available to the civil and environmental professional throughout the life cycle of a project, from data collection and analysis through software, project management, environmental impact analysis, visualization, and infrastructure asset management. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

CEE 5094:**CII Best Practices**

Introduction to Construction Industry Institute (CII) Best Practices, including Front End Planning Zero Accident Techniques, Constructability, and Material Management that affects construction projects. Management influences on construction processes and critical issues. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CEE 5100:**Stormwater Treatment**

Stormwater quality. Basic traps, basins, and filters. Stormwater treatment. Basic vegetative control systems. Mechanistic role of wetland. Best management practices. Monitoring, sampling, analysis, and maintenance methods. Pre: Graduate Standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CEE 5104:**Environmental Chemistry**

Applied, environmental aspects of physical, organic, and inorganic chemistry; including applications in sanitary engineering of the phenomena of precipitation, complexation, buffering capacity, and chemical equilibria. Review of the nomenclature and properties of organic compounds.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CEE 5114:**Advanced Environmental Sustainability - A Systems Approach**

Advanced quantitative methods to evaluate environmental sustainability using a systems approach. Sustainability assessment frameworks, indicators of sustainable development, green-house gas emissions, renewable energy systems, whole-system design, economic systems and input- output techniques, system dynamics models, emergence and agent-based models. Emerging sustainability topics. Pre: Graduate Standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

CEE 5124:**Fundamentals of Environmental Toxicology**

Introduction to nomenclature, principles, and scope of environmental toxicology. The fate and effects of both organic and inorganic toxicants in the environment, in animals, and in various test systems.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): CEE 5104 (UG) OR CEE 5104

Corequisite(s):

CEE 5125:**Environmental Engineering Design**

5125: Design of wastewater treatment facilities for the reduction and elimination of organic and inorganic pollutants; 5126: Design of water treatment facilities for the production of potable waters from surface and

groundwater systems. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

CEE 5126:**Environmental Engineering Design**

5125: Design of wastewater treatment facilities for the reduction and elimination of organic and inorganic pollutants; 5126: Design of water treatment facilities for the production of potable waters from surface and groundwater systems.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CEE 5130 (ESM 5554):**Turbulence and Turbulent Flows**

Nature and origin of turbulence, turbulent transport of momentum and heat, the dynamics of turbulence, statistical description of turbulence and spectral analysis. Examples of turbulent flows, boundary layers.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CEE 5134:**Engineering Aspects of Water Quality**

The application of biological, chemical, and physical principles of water quality to engineering problems in surface waters. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

CEE 5144:**Unit Operations and Processes Laboratory**

Applied science aspects of water and waste treatment; advanced research techniques in analysis and treatment of water and wastes.

Credit Hour(s): 0 OR 3

Lecture Hour(s): 0 OR 1

Instruction Type(s): Lab, Lecture, Online Lecture

Instruction Type(s): Lab, Lecture, Online Lecture

Prerequisite(s): (CEE 5125 (UG) OR CEE 5126 (UG)) OR (CEE 5125 OR CEE 5126)

Corequisite(s):

CEE 5154:

Air Pollution Transport and Chemistry

Air pollutant emissions, transformation, transport, and fate. Global climate change, ozone chemistry, air pollution modeling, particle dynamics, and air quality management. Pre: Graduate Standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CEE 5164:

Environmental Biotechnology

Introduction to environmental biotechnologies for wastewater treatment. Fundamentals of environmental microbiology. Engineering principles for applying biotechnology to address environmental pollution control.

Advanced biotechnologies, membrane bioreactors, and algal bioreactors. Sustainable environmental remediation and protection. Pre: Graduate Standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CEE 5184:

Techniques for Environmental Analysis

An introductory course on techniques commonly utilized for analysis of environmental samples. Course will discuss gas and liquid chromatography, mass spectrometry, and atomic absorption spectroscopy, focusing on analysis of complex environmental samples.

Practical techniques and applications are emphasized, but sufficient theory is introduced to provide students with an understanding of the principles involved.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CEE 5194:

Environmental Engineering Microbiology

Roles of microorganisms in wastewater treatment, anaerobic digestion of municipal sludges, stream self-purification, and degradation of water quality in drinking-water systems. Disinfection of wastewater and drinking water to remove viruses, bacteria, and protozoa that cause waterborne disease.

Credit Hour(s): 0 OR 3

Lecture Hour(s): 0 OR 2

Instruction Type(s): Lab, Lecture, Online Lecture

Instruction Type(s): Lab, Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CEE 5204:

Gis Applications in Civil Engineering

Examination of data structures used in geographic information systems. Map projections and coordinate systems used in mapping. Database creation, maintenance, and integrity. Applications of GIS methods for solving civil engineering problems in land management and related areas.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CEE 5224:

Advanced GIS Applications in Civil and Environmental Engineering

This project based course deals with both vector and raster Geographic Information Systems (GIS), network analysis, tracking applications, hydrologic applications, spatial analysis, web databases, and linking GIS to models with programming, specifically in the civil and environmental engineering arena. Pre: Any introductory GIS course, including CEE 5204, GEOG 4084, or BSE 4344. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

377 Prerequisite(s):

Corequisite(s):

CEE 5244 (BSE 5244):

Advanced GIS in Hydrologic Analysis

Advanced GIS course focusing on raster analysis with particular application to the issues associated with hydrologic analysis. Application and evaluation of algorithms for terrain analysis, watershed characterization, and hydrologic analysis and modeling as implemented in GIS. Digital elevation data sources and error assessment. Approaches to GIS/model integration and application. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 2

Instruction Type(s): Lab, Lecture, Online Lecture

Instruction Type(s): Lab, Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

CEE 5254:

Municipal Engineering

Field of municipal engineering. Infrastructure, capital projects, financing, sustainability, disaster planning and response, and municipal plan review techniques. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CEE 5264:

Sustainable Land Development

Contemporary techniques for developing land while maintaining a focus on long-term sustainability. Smart location and linkage, neighborhood pattern and design, conceptual design, stormwater strategies, green buildings and energy. Development standards such as Leadership in Energy & Environmental Design (LEED) and Envision. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

CEE 5264G:

Advanced Air resources Engineering

Effects, regulation, sources, and control of air pollution. Application of

engineering calculations and models to estimate emissions, predict pollutant concentrations, and design pollution control equipment.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CEE 5274:

Land Development Design Projects

Analysis of land development projects. Land development industry, government policies and regulations, legal topics, engineering design, and construction practices. Site feasibility analysis, site planning, environmental compliance, conceptual layout, and ADA compliance. Design of major infrastructure systems. Use of computer aided drafting and design software. Design project. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CEE 5304:

Environmental Fluid Mechanics

The first part of the course will be devoted to basic concepts and equations of fluid motion. The remainder of the course will be concerned with the theory of incompressible viscous and inviscid fluids. Selected applications will be drawn from environmental and water resources topics. Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

CEE 5314:

River Mechanics and Sediment Transport

Sediment properties; critical stress; bed-form regimes in alluvial streams; depth-discharge relations for rivers; bed load and suspended load movement; river stability; flow in bends; river training. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

CEE 5324:

Advanced Hydrology

Applications of statistics to hydrology, floods, and droughts; flow generation models; mathematical models in physical hydrology; difference methods in flow routing; kinematic wave; evapo-transpiration; infiltration; and atmospheric processes. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

CEE 5334:

Analysis of Water Resources Systems

Introduction to quantitative hydrology. Diverse computational aspects within watersheds. Methods and models used to examine components of hydrologic cycle. Risk analysis and statistical probability in hydrology. Comprehensive models for watershed management and urban hydrology. Pre: Graduate Standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CEE 5344:

Surface Water-Groundwater Interaction

Interaction (exchange) of surface water with groundwater at watershed, reach, sediment-patch scales including bidirectional hyporheic flows. Focus on streams and rivers, consideration of lakes. Steady and unsteady exchange hydraulics including laminar and turbulent flows. Exchange benefits and engineering goals including heat transfer, nutrient processing, and contaminant attenuation. Engineering applications including conjunctive use of surface water and groundwater resources and impact of groundwater pumping on rivers. Field methods.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

CEE 5354 (GEOS 5814):

Numerical Modeling of Groundwater

Theory and practice of numerical techniques are developed and applied to fluid flow and transport in ground-water flow systems. Governing equations are formulated using FD and FE techniques with appropriate BCs and ICs. Additional topics include: model conceptualization and grid design in multidimensional systems; practical applications of numerical models including calibration, validation, and prediction; concepts and techniques of advective transport using particle tracking and dispersive transport. Introduction to MODFLOW, MODPATH, MT3D, and others. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

CEE 5364:

Water Law

Analysis of law for allocation of surface and groundwater supplies, legal controls over water quality alteration, public rights of water use, and drainage law. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

CEE 5374:

Dynamics Groundwater

The theory of dynamics of fluids in porous media; fluid and matrix properties; transport equations; boundary and initial value problems; flow of immiscible fluids; dispersion. Pre: Graduate Standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

CEE 5384:

Transport Processes in Waterways

Advanced treatment of the mechanics of open channel flow, including uniform flow, gradually varied flow, channel transitions, and unsteady

flow. Independent research project. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

CEE 5390:

Advanced Urban Water Sustainability

Climate change and the supply of freshwater. Coupled socio-hydrologic feedback loops (systems dynamics models) and implications for water systems resilience. Urban water transitions theory and the evolution of water systems through time. Water productivity. Stormwater capture and reuse, green stormwater infrastructure, and ecosystem services.

Decentralized water and wastewater treatment systems. Emphasis is placed on the social (equity), environmental, and technological context in which urban water systems operate. Advanced statistical computing is used to quantitatively explore urban water systems challenges. Pre:

Graduate Standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CEE 5400:

Design of Prestressed Concrete

Principles of prestressing applied to single and multiple span concrete beams, beams with composite slabs, and two-way slabs. Design of individual elements of prestressed concrete for allowable stresses, flexural strength and shear that satisfy industry standards. Pre: Graduate Standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CEE 5410:

Intermediate Reinforced Concrete Structures

Behavior and design of reinforced concrete structures subjected to gravity and lateral loads. Moment-curvature relationships for reinforced concrete beams with and without confinement. Collapse mechanisms and redistribution in continuous members. Development length, slender

columns, two-way floor systems, and combined shear and torsion. Pre: Graduate Standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CEE 5414:

Finite Element Analysis of Structures

Formulation of the finite element method and application to skeletal, plate, and shell structures. Study of mesh layout and refinement, convergence characteristics, and solution accuracy. Tests of element quality. Use of commercial finite element codes such as ABAQUS.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CEE 5420:

Computer Methods of Structural Analysis

Formulation of the matrix displacement method in a form suitable for program development. Application to trusses, continuous beams, grids, and frames. Incorporation of special features such as constraints, rigid ends, internal releases, and support settlements. Initiation and modification of existing programs on the personal computer. Pre:

Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CEE 5424:

Computer Analysis of Structures II

Extension of matrix displacement method to skeletal space structures: space trusses, space frames, and grids. Incorporation of special features such as nonglobal constraints, assemblies of different types of elements, thermal problems, substructuring, and buckling analysis. Development of well-structured programs on the mainframe and transfer to the personal computer. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

CEE 5424G:

Intermediate Design of Prestressed Concrete Structures

Principle of prestressing applied to concrete beams, slabs, and frames; design of individual elements and structural systems of prestressed concrete; precast construction and connection design. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

CEE 5430:

Intermediate Design of Steel Buildings

Design of major components in steel-framed buildings, including composite beams and slabs, beam-columns, and moment connections. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CEE 5434:

Design of Cold-formed Steel Structures

Behavior and design of cold-formed steel members. Strength of thin plate elements; flexural members; compression members, symmetric and non-symmetric; beam-columns; welded, bolted, and screw-fastened connections. Building systems that utilize cold-formed steel members. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

CEE 5440:

Instrumentation and Signal Processing for Civil Engineering Applications

Fundamental operating principles and implementation guidelines for instrumentation in civil engineering. Measurements for strain and load, acceleration, temperature, pressure. Data acquisition and signal processing concepts, sampling, filtering, and frequency domain analysis. Statistics, uncertainty analysis, and experimental methods applied to sensor measurements. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CEE 5444:

Stability of Structures

Methods of static structural stability analysis and their applications. Buckling of columns and frames. Energy method and approximate solutions. Elastic and inelastic behavior. Torsional and lateral buckling. Use of stability as structural design criterion. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

CEE 5450:

Forensic Struct Engineering

Cultural and technical basis for concepts of risk and failure, formal approaches to failure investigation, origins of natural and man-made disasters, the role of building codes, standard of care, ethical standards, community resiliency, and legal issues as related to forensic structural engineering. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CEE 5454:

Blast Resistant Design of Structures

Explosion sources and blast waves. Computation of blast load parameters. Single degree of freedom dynamic analysis of blast loaded components. Material behavior at high strain rates. Protective design and detailing of concrete and steel structures and non-structural components. Retrofitting and hardening of existing structures. Pre:

Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

CEE 5464:

Structural Dynamics and Earthquake Engineering

Earthquake-induced vibration of single- and multi-degree-of-freedom systems; application to frames and to shear and torsional buildings; response spectrum analysis; building codes; static and dynamic lateral force procedures; seismic resistance of steel and concrete building frames. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s): null null

CEE 5470:

Structural Design for Seismic Load Effects

Analysis and design of steel and reinforced concrete structures for seismic load effects. Fundamental principles of earthquake engineering, as rooted in seismic hazard analysis, inelastic behavior, and dynamic response. Application of these principles to the design and detailing of reinforced concrete and structural steel buildings. Building code requirements for seismic loading and seismic resistant design.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): CEE 5464

Corequisite(s):

CEE 5474:

Advanced Reinforced Concrete Design

Limit design concepts, yield-line methods, seismic considerations, and other advanced topics related to design of reinforced concrete structures. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

CEE 5474G:

Intermediate Reinforced Concrete Structures

Behavior and design of continuous reinforced concrete structures subjected to gravity and lateral loads. Application of computer programs to frame analysis and design of members. Development length, biaxial bending of columns, continuous one-way beams and slabs, two-way floor systems, torsion, footing, and cantilever retaining wall design problems. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

CEE 5480:

Steel Bridge Design

Design and analysis of primary bridge components including concrete decks, steel plate girders, and bracing members. Moving loads, and load combinations specific to bridges using current design codes. Fatigue and fracture limit states from repetitive vehicular loads. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CEE 5490:

Structural Mechanics

Mechanics of civil materials and structural components. Fundamentals of elasticity. Bending of beams, beam-columns, and thin plates. Energy methods for boundary value problems. Stability conditions. Failure criteria, introductory fracture mechanics, and plasticity theories. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CEE 5494:

Theory of structural reliability; reliability based designs, safety index, linear and nonlinear design equations, load and resistance factors, Level I, II and III formats, code formulations; systems reliability, bounds on reliability.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

CEE 5500:

Numerical Methods in Geotechnics

Numerical modeling of geotechnical systems. Numerical methods in geotechnics. Finite element method, formulation of boundary value problems, principles of coupled hydromechanical analysis. Structure and use of finite element software.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): CEE 5514

Corequisite(s):

CEE 5504:

Risk Analysis Geotechnical Engineering

Methods for risk analysis of complex systems. Basic concepts of probability and reliability applied to geotechnical engineering problems. Geostatistics concepts. Probabilistic seismic hazard analysis and performance based design. Computational tools and simulation methods. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CEE 5514:

Soil Behavior

Behavior of soil examined from a fundamental soil perspective. Review of methods of testing to define response; rationale for choosing shear strength and deformation parameters for soils for design applications. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

CEE 5524:

Advanced Soil Testing for Engineering Purposes

Methods of testing and analysis of soil for engineering properties including compressibility; strength in triaxial, simple, and direct shear; permeability; and stability. Pre: Graduate standing.

Credit Hour(s): 0 OR 3

Lecture Hour(s): 0 OR 1

Instruction Type(s): Lab, Lecture, Online Lecture

Instruction Type(s): Lab, Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

CEE 5534:

Foundation Engineering I

Behavior and design of retaining walls and shallow foundations. Earth pressures, bearing capacity, and settlement. Stress distribution and consolidation theories. Settlement of shallow foundations. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

CEE 5544:

Foundation Engineering II

Behavior and design of anchored bulkheads, excavation bracing, driven piles, drilled piers and buried structures. Effects of pile driving. Response of deep foundations to vertical and horizontal loads.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): CEE 5534 (UG) OR CEE 5534

Corequisite(s):

CEE 5554:

Soil and Site Improvement

Methods of soil and site improvement including design techniques for dewatering systems, grouting, reinforced earth, in-situ densification, stone columns, slurry trenches, and the use of geotextiles. Construction techniques for each system are described. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

CEE 5564:

Seepage and Earth Structures

Soil permeability and seepage through soils. Embankment design. Compaction, earth pressures and pressures in embankments. Slope stability analysis. Settlements and horizontal movements in embankments. Landslide stabilization.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): CEE 5514 (UG) OR CEE 5514

Corequisite(s):

CEE 5584:

Geotechnical Aspects of Earthquake Engineering

Causative mechanisms of earthquake, earthquake magnitudes, ground motion, effect of local soil conditions on motions. Response of soils to seismic loading, liquefaction phenomena and analysis of pore pressure development, laboratory and in-situ testing for seismic loading. Analysis and design of slopes, embankments, foundations, and earth retaining structures for seismic loading. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

CEE 5594:

Geological Engineering

Mechanical and hydraulic properties of rock masses; analysis and design of rock foundations, slopes, tunnels, and other forms of civil infrastructure; rock reinforcement. Pre: Graduate Standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CEE 5600:

Civil Infrastructure Systems Analysis

Systems analysis, modeling infrastructure systems by mathematical programming, measuring infrastructure systems performances, probabilistic analysis of infrastructure systems, multiple attribute decision making in infrastructure systems. Pre: Graduate standing in engineering is required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CEE 5604:

Traffic Characteristics and Flow

Driver, vehicle, and roadway characteristics; stochastic modeling of traffic processes including queueing theory, headway distributions, and gap acceptance; stream flow characteristics including car-following and multilane traffic models, roadway capacity and bottleneck analysis, network operations, and fuel consumption models. Pre: Graduate standing.

Credit Hour(s): 0 OR 3

Lecture Hour(s): 0 OR 2

Instruction Type(s): Lab, Lecture, Online Lecture

Instruction Type(s): Lab, Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

CEE 5610:

Advanced Mechanics of Composite Materials

Introduction to the deformation, stress, and strength analysis of continuous-fiber-polymer-matrix laminated composites. Fabrication, micromechanics of stiffness and expansional coefficients, classical lamination theory. Environmentally induced stresses. Computerized implementation and design. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CEE 5614:

Analysis of Air Transportation Systems

Planning, design and operation of aviation systems with computer aided design tools and computer simulation models. Airline airport operations

and practices and their effect in airport planning and design. Air cargo facilities planning and modeling. State-of-the-art computer simulation models used in aviation environmental planning and airspace modeling. Graduate standing in CE required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CEE 5620:

Transportation Network Analysis

Optimal paths in transportation networks, transportation network design, vehicle routing and scheduling, facility location problems, traffic flows on networks, traffic assignment problems.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CEE 5624:

Transportation and Land Use

Interaction between transportation and land use variables, including modeling requirements, impacts, and data needs within the context of good community planning and economic development; elements of transportation and land use that shape the quality of life in urban areas.

Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

CEE 5634:

Analysis and Planning of Mass Transit Systems

An overview of mass transit systems; transit system planning including demand and cost analysis and evaluation; transit system design including route design, scheduling, and fare policy; transit networks and marketing; para transit systems; future trends in mass transit. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

CEE 5640:

Highway Transportation Safety

Identification of highway safety problems and development of solutions. User characteristics and expectations, road audits, roadside hardware systems, safety enhancing treatments, standard traffic control devices, real-time information and control systems, work zone and railroad crossing treatments, older driver design concepts, traffic calming, designs for pedestrians and bikes, delineation and lighting principles, and advanced 3D/4D design concepts. Group and individual analyses of problems. Pre: Graduate standing in engineering is required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

CEE 5644:

Transportation Systems Planning

Advanced consideration of problems dealing with transportation systems as they affect the socio-economic development of cities, regions, and nations; the travel behavior of a populace; the location of economic activity; the use of land; and the allocation of resources. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

CEE 5650:

Freight Operations & Planning

Introduction to the operation of modal and intermodal freight facilities and operation. Types of freight movement and handling equipment, freight planning methods, and research. Freight as a multi-modal transportation system. Role of privately owned and operated freight movement on public sector transportation operations and decision making. Communication of impacts of freight movement. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

385 Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CEE 5654:

Critical Issues in Transportation

Technological, societal, economic, political, environmental, health, and energy effects on planning, design, operation, and management of the transportation system. Modeling of complex interactions and causal relationships among current issues. Principles of optimization for design and operation of the five basic elements of transportation (vehicles, networks, terminals, controls, and system administration). Problem definition, objectives identification, model development, alternatives generation and evaluation, and reasoning process for transportation investment. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

CEE 5660:

Transportation Risk, Reliability & Security

Transportation risk assessment and computation; evacuation modeling; reliability analysis; infrastructure interdependency analysis; network impact assessment. Pre: Graduate Standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

CEE 5674:

Advanced Pavement Design

Methods used to characterize, stabilize, and specify pavement materials. Methods for rigid and flexible highway and airport pavement design and analysis. Load equivalence factor and specific design considerations related to environment and traffic characteristics. Pavement overlay design. Software for pavement design and analysis using various models. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

CEE 5684:

Rehabilitation of Transportation Structures

Identification of maintenance and rehabilitation needs for transportation structures such as bridges and pavements. Cost effective maintenance and rehabilitation methods. Consideration of bridge and pavement management systems.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CEE 5694:

Traffic Signal System Operation and Control

Traffic signal system control, with emphasis in arterial operation. Signal system design and operations, traffic simulation techniques, advanced traffic control strategies, and incorporation of surface street systems into Intelligent Transportation Systems (ITS). Hands on experience in signal system software and hardware. Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CEE 5704 (PHS 5704):

Drinking Water & Health

Drinking water contamination and associated health outcomes. Programs to improve safe water access. Viral, bacterial, protozoal, and helminthic pathogens. Heavy metals, pesticides, and other contaminants. Drinking water treatment and supply in rural areas. Study designs for health outcome assessment. Field-based intervention trials. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s): null null

CEE 5714:

Surface Water Quality Modeling

386 Use, analysis, and development of water quality models for lakes, rivers,

and estuaries. Emphasis on model calibration, verification, and post-audit analysis. Lab portion will develop and apply a eutrophication model for an estuary using existing data.

Credit Hour(s): 0 OR 3

Lecture Hour(s): 0 OR 2

Instruction Type(s): Lab, Lecture, VB, Online Lecture

Instruction Type(s): Lab, Lecture, VB, Online Lecture

Prerequisite(s):

Corequisite(s):

CEE 5724:

Environmental Monitoring and Sampling

Experimental design and sampling techniques for environmental analysis, including environmental monitoring techniques and statistical principles for planning monitoring locations and frequencies at environmental sites such as landfills, rivers, lakes, and the atmosphere. Development of monitoring strategy; examination of sampling techniques for various sample types.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s): CEE 5104

CEE 5734:

Urban Hydrology and Stormwater Management

Development of methods and numerical models for computing surface runoff from developing watersheds; hydraulics of combined sewer systems; urban non-point source pollutant load calculations and best-management practices; control strategies for regional stormwater management; detention basin design for control of urban floods and non-point source pollutants. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

CEE 5744:

Topics in Structural Steel Design

Calculation of stresses in steel members. Overall-local buckling interaction. Design of singly symmetrical and unsymmetrical columns and topics on flexural design, design of plate girders, bracing design, and design of framing connections. Pre: Graduate standing

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

CEE 5754:

Pavement and Bridge Infrastructure Management Systems

Management concepts used in civil infrastructure; planning, design, construction, maintenance, and rehabilitation of bridge and highway systems. Prioritization, optimization, and decision-making techniques. Life-cycle-cost prediction. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

CEE 5764:

Asphalt Technology

Origin, types and properties of bituminous materials and their use in civil engineering. Asphalt rheology. Theory behind technological processes and procedures for hot-mix asphalt including design philosophy, performance, and durability. Modern construction with bituminous materials; special mixtures, recycling, and additives. Pre: Graduate standing.

Credit Hour(s): 0 OR 3

Lecture Hour(s): 0 OR 2

Instruction Type(s): Lab, Lecture, Online Lecture

Instruction Type(s): Lab, Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

CEE 5774:

Hazardous Waste Management

Review of regulatory framework governing hazardous waste management. Characteristics of hazardous wastes. Fundamental physical, chemical, and biological principles applied to the design of treatment processes. Risk management. Case studies. Design project. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s): CEE 5104

CEE 5784:**Special Topics in Portland Cement Concrete**

Advanced tools and approaches for supporting more sustainable transportation infrastructure investment decisions by balancing technical, economic, environmental, and social objectives. Selection of sustainable materials, systems and management approaches. Mitigation and adaptation to climate change. Cost and environmental life-cycle assessment methods and tools pertaining to transportation systems.

Pre: Graduate standing.

Credit Hour(s): 0 OR 3

Lecture Hour(s): 0 OR 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

CEE 5794:**Environmental Engineering Principles**

Examines the basic physical, chemical, and microbiological principles that provide the foundation for environmental engineering. Illustrates how these principles are applied to solve a wide range of environmental problems. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s): CEE 5104

CEE 5804:**Engineering Ethics and the Public**

Moral obligations of engineers and scientists toward the publics they serve; responsible conduct of research; responsible conduct of practice; the responsibilities and risks of witnessing wrongdoing; the value of non-expert knowledge claims and the importance of listening to public stakeholders. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CEE 5814:**Structure-Sediment Interaction**

Scour processes at structure foundations in the coastal zone. Erosion

and undermining at port walls, pipelines, piers, jetties, breakwaters, artificial reefs. Foundations and moorings for nearshore renewable energy devices. Sediment remobilization and liquefaction as a consequence of cyclic loadings and extreme events. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CEE 5834:**Asphalt & Pavement Modeling**

Characterization of asphaltic concrete microstructure. Relations to macroscopic properties. Pavement performance modeling. Pre: Graduate Standing

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CEE 5844 (AOE 5844):**Ocean and Coastal Wave Mechanics**

Linear wave theory including boundary value problems, wave transformation in shallow waters, long waves, and engineering properties of waves. Introduction to nonlinear wave theories. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CEE 5854G:**Advanced Coastal Engineering**

Basic wave mechanics principles, surf-zone processes, littoral and sediment processes, shoreline features, astronomical tides, coastal hazards, and functional design of coastal structures. Field trips. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CEE 5864:

Coastal and Estuarine Morphodynamics

Sediment transport in marine environments, shoreline change, bedform evolution and morphodynamics, tidal inlet morphodynamics, barrier island processes, storm erosion, delta development, beach dynamics. Evolution of estuarine waterways and wetland systems. Pre: Graduate Standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CEE 5874:

Coastal and Marine Geotechnics

Geotechnical aspects of coastal and marine engineering. The coastal zone as a working environment. Geotechnical properties of beach and seafloor sediments, methods and processes for subaqueous and coastal site investigations, complementary techniques for investigation. In-situ survey strategies, planning and management. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CEE 5884:

Legal Aspects of Civil, Construction and Environmental Engineering

Analysis of relevant federal and state law (commercial law, contracts law, environmental law) in application to the design and construction of civil and/or environmental engineering projects, as well as water and wastewater treatment and management. Professional liability, risk management and environmental regulatory compliance issues. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CEE 5894:

Final Examination

NONE

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CEE 5904:

Project and Report

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research, Online Research

Instruction Type(s): Research, Online Research

Prerequisite(s):

Corequisite(s):

CEE 5944:

Seminar

Review and discussion of current literature, research, and consulting activities by student, faculty, and guest speakers.

Credit Hour(s): 1

Lecture Hour(s): 1

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CEE 5974:

Independent Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Independent Study, Online Lecture

Instruction Type(s): Independent Study, Online Lecture

Prerequisite(s):

Corequisite(s):

CEE 5984:

Special Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

389 Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CEE 5994:

Research and Thesis

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research, Online Research

Instruction Type(s): Research, Online Research

Prerequisite(s):

Corequisite(s):

CEE 6104:

Advanced Environmental Chemistry

Advanced theories and practices in environmental engineering with special emphasis on inorganic aspects of water chemistry; application of water chemistry fundamentals for the description of aquatic systems.

Pre: Graduate standing.

Credit Hour(s): 2

Lecture Hour(s): 2

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

CEE 6114:

Advanced Topics in Air Quality Engineering

Review and critique of current research. Emissions, transport, transformation, and fate of gases and particles in the atmosphere. May be repeated with different topic content for a maximum of 3 credits. Pre: Graduate standing.

Credit Hour(s): 1

Lecture Hour(s): 1

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

CEE 6404:

Dynamics of Structures

Formulation of equations of motion by the finite element method. Solution by mode superposition and direct methods. Earthquake analysis and nonlinear analysis. Application to skeletal and plate structures. Development of computer programs and use of commercial programs. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): (CEE 5414 (UG), ESM 4074 (UG)) OR (CEE 5414, ESM 4074)

Corequisite(s):

CEE 6414:

Nonlinear Finite Element Analysis for Solids and Structures

Nonlinearities encountered in solid and structural mechanics. Finite element formulation of nonlinear truss and beam problems. Nonlinear solid mechanics and plasticity theory. Algorithmic implementation of elasto-plastic constitutive models. Implicit and explicit solution procedures for finite element analysis of nonlinear static and dynamic problems.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): CEE 5414

Corequisite(s):

CEE 6424:

Advanced Prestressed Concrete

Behavior and design of prestressed slabs, bridges, and precast building systems. Continuous prestressing; load-balancing method for slabs; torsion and shear; connections for precast members; partial prestressing. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

CEE 6434:

Advanced Steel Design

Advanced topics of current interest in structural steel design research as given by recent publications and informal reports. In-depth study of selected projects. May be repeated. 12 credits of 5000-level courses in structures or solid mechanics required. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

390 Prerequisite(s): null null

Corequisite(s):

CEE 6504:

Theoretical Soil Mechanics

Constitutive Laws for Soils, nonlinear elastic and plastic models. Consolidation, layered systems, sand drains, approximate three-dimensional theories, and Biots poro-elastic formulation. Plastic equilibrium in soils Sokolovskis method of characteristics, applications to earth pressure, bearing capacity, and slope stability problems. Analysis of machine foundation problems, elastic waves through soils, dynamic properties of soils.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): CEE 5514 (UG) OR CEE 5514

Corequisite(s):

CEE 6514:

Dynamics of Soils and Foundations

Principles of the dynamics of soils and foundations. Seismic waves. Non-linear dynamic soil behavior and vibrations. Dynamic-soil-structure interaction. Impedance functions and machine foundation design.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): CEE 5584

Corequisite(s):

CEE 6844:

Current Topics in Coastal Eng

Contemporary challenges and research questions in coastal engineering. Review and critique of contemporary coastal engineering literature. May be repeated with different topic content for a maximum of 6 credits.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): CEE 5854G

Corequisite(s):

CEE 6984:

Special Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CEE 7994:

Research and Dissertation

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research, Online Research

Instruction Type(s): Research, Online Research

Prerequisite(s):

Corequisite(s):

ENVIRONMENTAL SCIENCES AND ENGINEERING

Mark Widdowson, Head

Emeriti Faculty: Gregory Boardman; William Cox; David Kibler; John Novak; Clifford Randall; Dusan Teodorovic;

Professors: Andrea Dietrich; Marc Edwards; Daniel Gallagher; Stanley Grant; Jennifer Irish; William Knocke; John Little; Linsey Marr; Amy Pruden-Bagchi; Peter Vikesland; Mark Widdowson;

Associate Professors: Erich Hester; Nina Stark; Kyle Strom;

Assistant Professors: Hosein Foroutan; Gabriel Isaacman-VanWertz; Landon Marston; Megan Rippy; Zhiwu Wang;

University Distinguished Professor: Marc Edwards;

Research Associate Professors: Adil Godrej;

Charles E. Via Jr. Professor: John Little;

Charles P. Lundsford Professor: Linsey Marr;

W. Thomas Rice Professor: Amy Pruden-Bagchi;

Nick Prillaman Professor: Peter Vikesland;

Assistant Professor of Practice: Robert Scardina; Claire White; Kevin Young;

Research Assistant Professors: Siddharth Saksena;

Graduate Contact: shmartin@vt.edu

Extended Campuses: shmartin@vt.edu

Graduate Site: <https://www.cee.vt.edu/prospective-graduate-students/>

Graduate Policy: <https://www.cee.vt.edu/wp-content/uploads/2018/07/Graduate-Policies-and-Procedures-Manual-Departmental.pdf>

The Environmental Science and Engineering (ESEN) program is designed to prepare undergraduates with a science background to work

with engineers in various fields including, water supply, wastewater management, public health, watershed management, stream protection, groundwater remediation and air resource management. Appropriate disciplines include, but are not limited to biology, chemistry, geology, agronomy, soil science and environmental science. A wide range of courses can be taken to fulfill the degree requirements, depending on the background and interests of the student. The purpose of the core curricula is to develop an understanding of the applicable chemical, physical, biological, and mathematical modeling fundamentals and then teach students how to apply these principles, along with their previous scientific training, to the solution of environmental problems. Appropriate employment is with consulting firms, regulatory agencies, municipalities and industry. The program administratively is under the direction of the Head of the Department of Civil and Environmental Engineering (<http://www.cee.vt.edu/>) and the program direction is by a faculty committee from Departments in the College of Engineering, Agriculture and Science.

SPECIAL FACILITIES

CEE offers a variety of labs for students who are participating in research. Please see the information listed under facilities to read about our labs locations.

Computing Facilities

The Civil and Environmental Engineering Computer Lab (CEECL) is maintained as a state-of-the-art collaborative learning environment. The instructional lab provides excellent multimedia equipment for faculty to demonstrate and instruct students in the use of computing tools through the Department's curriculum. Faculty and students also have access to a variety of supercomputing facilities and data visualization capabilities through the computer resources of Virginia Tech.

Experimental Facilities

Experimental Facilities The Environmental Science and Engineering (ESEN) program occupies modern laboratories in Durham, Patton, Kelly, Steger and Hancock Halls. Laboratories and specialized experimental and analytical equipment support research programs related to areas such as water and wastewater treatment, hazardous and residuals waste management, water quality management, environmental chemistry, and air quality. Available equipment allows for the identification and quantification of most chemical and microbial environmental contaminants. The water resources engineering laboratories support basic and applied research activities in the areas of water, sediment, and pollutant movement in surface and groundwater sources. The Kelso Baker Environmental Hydraulics Laboratory houses two large (each 70 ft. long) tilting flumes, a medium length tilting flume, a 3-D laser Doppler velocimeter, a hot film anemometer, and numerous pieces of support instrumentation.

Occoquan Watershed Monitoring Laboratory (Manassas, Virginia)

The environmental science and engineering program also includes the Occoquan Monitoring Laboratory (Manassas, Virginia), where research focuses on runoff pollutant effects on receiving waters, reservoir eutrophication control, and watershed monitoring and management. Web

site: www.owml.vt.edu

Potomac Aquifer Recharge Monitoring Laboratory (Hampton, Virginia)

The PARML, Hampton, is responsible for making determinations in a number of areas critical to the ongoing management of water quality in the Potomac aquifer, situated in the Hampton Roads area of Southeast Virginia. This work is in association with managed aquifer recharge associated with the \$1 billion SWIFT (Sustainable Water Initiative For Tomorrow) project.

DEGREES OFFERED

MS Degree

Offered In (Blacksburg, National Capital Region)

TOEFL

iBT: (90.0)

GRE

General: Verbal, Quantitative, Analytical

MS ESEN degree may be taken either as coursework only or with the permission of the faculty may incorporate a project & report or a research thesis. See Departmental Manual:<https://www.cee.vt.edu/wp-content/uploads/2019/07/Graduate-Policies-and-Procedures-Manual-Departmental.pdf>

INDUSTRIAL AND SYSTEMS ENGINEERING

Eileen Van Aken, Head

Professors: John Casali; Brian Kleiner; Michael Madigan; Maury Nussbaum; Subhash Sarin; Gaylon Taylor; Konstantinos Triantis; Kwok Tsui; Eileen Van Aken;

Associate Professors: Deborah Dickerson; Kimberly Ellis; Joseph Gabbard; Lawrence Harmon; Myoungsoon Jeon; Sheila Klauer; Zhenyu Kong; John Shewchuk; Michael Taaffe;

Assistant Professors: Manish Bansal; Xi Chen; Navid Ghaffarzadegan; Robert Hildebrand; Niyousha Hosseinichimeh; Ran Jin; Blake Johnson; Hanumanthrao Kannan; Andrea L'Afflitto; Nathan Lau; Alejandro Salado Diez; Divya Srinivasan; Sait Tunc; Weijun Xie; Xiaowei Yue;

John Grado Professor: John Casali;

Ralph H. Bogle Jr. Professor: Brian Kleiner;

Hal G. Prillaman Professor: Maury Nussbaum;

Paul T. Norton Endowed Professor: Subhash Sarin;

Charles O. Gordon Professor: Gaylon Taylor;

John Lawrence Professor: Konstantinos Triantis;

Research Assistant Professors: Rafael Patrick;

Main Campus Graduate Program Contact: hsswiger@vt.edu

Off Campus Graduate Program Contact: hsswiger@vt.edu

Graduate Site: <https://www.ise.vt.edu/academics/graduate.html>

Main Website: <https://www.ise.vt.edu/index.html>

Graduate Admissions Information:

<https://www.ise.vt.edu/academics/graduate/application.html>

The Grado Department of Industrial and Systems Engineering (ISE) offers a broad-based program allowing students to pursue graduate study commensurate with their career goals. Specific strengths of the program are in the areas of human factors engineering and ergonomics, general industrial engineering, management systems engineering, manufacturing systems engineering, operations research, engineering administration, and systems engineering. The Ph.D. degree is offered in Industrial and Systems Engineering, and the master's is offered in Industrial and Systems Engineering (MS & MENG), Engineering Administration (MEA), and Systems Engineering (MS).

SPECIAL FACILITIES

Creating and maintaining state-of-the-art facilities is one of the most challenging aspects of a top 10 ISE department. Through private giving, research sponsorship, equipment donations and state support, we strive to provide the very best technology for our students and sponsors. For more information on our many labs, centers and other facilities, see the facilities page of the ISE web site:

<https://www.ise.vt.edu/about/facilities.html>

Centers

<https://www.ise.vt.edu/about/facilities/centers.html>

Labs

<https://www.ise.vt.edu/about/facilities/labs.html>

DEGREES OFFERED

MS Degree

Offered In (Blacksburg)

GRE

General: Verbal (146.0), Quantitative (151.0), Analytical (3.0)

TOEFL

iBT: (90.0)

<https://www.ise.vt.edu/academics/graduate/ms.html>

Degree Concentrations:

Human Factors Engineering and Ergonomics

<https://www.ise.vt.edu/academics/graduate/ms/hfee.html>

Management Systems Engineering

<https://www.ise.vt.edu/academics/graduate/ms/mse.html>

Manufacturing Systems Engineering

<https://www.ise.vt.edu/academics/graduate/ms/mfg.html>

Operations Research

<https://www.ise.vt.edu/academics/graduate/ms/or.html>

General Industrial Engineering

<https://www.ise.vt.edu/academics/graduate/ms/gie.html>

PhD Degree

Offered In (Blacksburg)

GRE

General: Verbal (146.0), Quantitative (151.0), Analytical (3.0)

TOEFL

iBT: (90.0)

Information on all PhD concentrations can be found on the ISE website

<https://www.ise.vt.edu/academics/graduate/phd.html>

MEA Degree

Offered In (Roanoke, Richmond, Hampton Roads, Southwest Virginia, Leesburg, National Capital Region)

TOEFL

iBT: (90.0)

GRE

General: Verbal (146.0), Quantitative (151.0), Analytical (3.0)

<https://www.ise.vt.edu/academics/extended/mea.html>

PhD Degree

Offered In (National Capital Region)

GRE

General: Verbal (146.0), Quantitative (151.0), Analytical (3.0)

TOEFL

iBT: (90.0)

<https://www.ise.vt.edu/academics/extended/phd.html>

MEng Degree

Offered In (Blacksburg)

TOEFL

Paper: (577.0)

iBT: (90.0)

GRE

General: Verbal (146.0), Quantitative (151.0), Analytical (3.0)

<https://www.ise.vt.edu/academics/graduate/ms.html>

GRADUATE COURSES (ISE)

ISE 5015:

Management of Change, Innovation & Performance in Organizational Systems

Control, management, and improvement of complex organizational

systems. A mix of theories and cases for designing and improving managerial processes such as planning, performance measurement, and evaluation, as well as organizational learning and leading change. 5015: Managing performance, learning, change, and innovation in organizational systems. Pre: Graduate standing. 5016: Measurement and evaluation of performance of organizational systems.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ISE 5016:

Management of Change, Innovation & Performance in Organizational Systems

Control, management, and improvement of complex organizational systems. A mix of theories and cases for designing and improving managerial processes such as planning, performance measurement, and evaluation, as well as organizational learning and leading change. 5015: Managing performance, learning, change, and innovation in organizational systems. Pre: Graduate standing. 5016: Measurement and evaluation of performance of organizational systems.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ISE 5015

Corequisite(s):

ISE 5024:

ISE Seminar

Discussion of research projects and results of sponsored and other research in the ISE Department and elsewhere, including descriptions of specialized equipment and facilities. In addition orientation to the department, its organization and operation is provided.

Credit Hour(s): 1

Lecture Hour(s): 1

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ISE 5034:

Mathematical Probability and Statistics for Industrial Engineers

One-semester mathematical foundations for graduate study of engineering oriented probability and statistics. Re-introduces probability

in a rigorous mathematical fashion and re-introduces mathematical statistics as an application of mathematical probability. Establishes a solid mathematical foundation for the type of probability (and statistics) modeling and analysis that is characteristic of graduate industrial engineering curricula and practice. Pre-requisite: Graduate Standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ISE 5044:

Production Systems Analysis

Principles, models, and methods for addressing operational problems in manufacturing systems. Application of fundamental measures such as cycle time, throughput, capacity, work-in progress, inventory, and variability for understanding, controlling and optimizing performance.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s): ISE 5034, ISE 5405

ISE 5104:

Operations Research

Basic techniques and methods of Operations Research are presented. The course will cover the phases of problem identification, model building and analytical methods of decision making. Students will be introduced to the implementation of these algorithms and models. Not for credit for students pursuing the M.S. or Ph.D. in the O.R. option.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ISE 5114:

Case Studies in Industrial Engineering

Applications of the methodologies in Industrial Engineering and Operations Research to actual problems in Business, Industry and Government operations. The study will cover all the phases of analysis, problem description, system structure, model development and validation and solution techniques. Student involvement in the case

studies will be accomplished through project assignments. Not for credit for M.S., M.E., or Ph.D. degrees in ISE.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ISE 5104, ISE 5434, STAT 5004

Corequisite(s):

ISE 5124:

Management of Quality and Reliability

This course presents the managerial and mathematical principles and techniques of planning, organizing, controlling, and improving the quality and reliability functions of an organization. The approach taken is to study the management of quality and reliability through the product life cycle, i.e., from research and development, through testing and analysis. The implementation of the managerial and mathematical techniques will be achieved through the study of selected case studies.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): STAT 5004

Corequisite(s):

ISE 5134:

Management Information Systems

Systems approach to management, domains of responsibility, structured and synergistic management tools, management system model, contextual frameworks, information portrayal, automation objectives model, evaluation, shared information processing, information modeling.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ISE 5144:

Performance and Productivity Measurement and Evaluation

This course presents the principles and techniques of performance management at the organizational level. Emphasis is placed on the measurement of performance with a focus on productivity measurement, as well as on performance evaluation and how these areas facilitate performance planning, control and improvement. Each student will be required to complete a project which will emphasize the application of these techniques to an organizational setting.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ISE 5154:

Applied Human Factors Engineering

An examination of present human engineering design criteria, principles, and practices to achieve mission success through integration of the human into system, subsystem, equipment, and facility design in order to achieve effectiveness, simplicity, efficiency, reliability and safety of system operation, training and maintenance. Not for credit for students pursuing the M.S. or Ph.D. in the Human Factors option.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ISE 5164:

Transfer and Application of Emerging Technology

Transfer of emerging technological developments from scientific discovery and invention through product development, leading to value-added applications in private sector and government enterprises. Market and technological research, forecasting, test and evaluation, outsourcing R & D, community/government support programs, legal protection and regulation of intellectual property, economic development, economic risk and similar issues supporting the management of technological innovation. Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ISE 5174:

Engineering Program and Project Management

The project approach as applied in the accomplishment and management of complex technical work typically performed by engineers, scientists and other technology professionals. Practical application and ongoing enhancement of program and project management systems with emphasis on process, techniques, standards,

considerations.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ISE 5204:

Manufacturing Systems Engineering

Conceptual models of manufacturing, process, and service organizations for various operational levels are presented. Functional activities and interrelationships are defined for each type of manufacturing model.

Typical objectives and operating constraints are identified for functional activities, particularly production planning/control, materials management, facilities design/material handling, manufacturing engineering, quality control, and personnel administration.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ISE 5244:

Facilities Planning and Material Handling

Fundamental quantitative approaches to facilities planning at multiple levels of the supply chain. Emerging strategies, principles, theories, and applications in facilities planning. Decision theory, deterministic and probabilistic mathematical models and solution algorithms for the facility layout and location problems, warehousing and storage systems, and material handling systems. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

ISE 5264:

Modeling and Analysis of Semiconductor Manufacturing

This course will present the modeling and analytical concepts and techniques used for the operational control of a semiconductor manufacturing facility. This will include the following: introduction to wafer fabrication, distinct features of a wafer fab, modeling techniques, planning and operational control problems in a wafer fab, lot sizing, and assembly test and packaging.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s): ISE 5204, ISE 5405

ISE 5314:

Industrial Applications of Robotics Devices

Technical aspects of robotics devices and automation islands employed by the industry are discussed in detail. On-line job teaching and off-line job planning for the industrial robot are compared. Various industrial applications including spray painting, welding, machine loading, and assembly are studied.

Credit Hour(s): 0 OR 4

Lecture Hour(s): 0 OR 3

Instruction Type(s): Lab, Lecture, Online Lecture

Instruction Type(s): Lab, Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

ISE 5405:

Optimization

5405: Linear programming, modeling, assumptions, and structural properties; primal, dual, and primal-dual simplex algorithms; convergence and implementation issues; duality theory; sensitivity and parametric analysis; linear multiobjective and goal programming, introduction to integer, dynamic, and nonlinear programming. 5406: Nonlinear programming theory and algorithms: convex sets and functions, generalized convexity; and theorems of the alternative, constraint qualifications, necessary, and/or sufficient optimality conditions.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ISE 5406:

Optimization

5405: Linear programming, modeling, assumptions, and structural properties; primal, dual, and primal-dual simplex algorithms; convergence and implementation issues; duality theory; sensitivity and parametric analysis; linear multiobjective and goal programming, introduction to integer, dynamic, and nonlinear programming. 5406:

functions, generalized convexity; and theorems of the alternative, constraint qualifications, necessary, and/or sufficient optimality conditions. II

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ISE 5405

Corequisite(s):

ISE 5414:

Random Process

Stochastic processes of use in many areas of study, specifically industrial engineering and operations research. Emphasis on Markov processes. Applications will be given.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ISE 5034

Corequisite(s):

ISE 5424:

Simulation I

Introduction to stochastic discrete-event simulation. Theoretical foundations for stochastic simulation methodology and design, and analysis of simulation experiments. Simulation modeling and programming in general-purpose languages and using some specialized simulation software packages. Applications are drawn from various settings, such as manufacturing, financial, logistics, and service systems. Course projects on solving a real-world decision-making problem under uncertainty, each involving building a simulation model based on a case description, conducting design of simulation experiments, and performing simulation-based analysis.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ISE 5034 OR STAT 5104

Corequisite(s):

ISE 5434:

Economic Evaluation of Industrial Projects

Application of engineering economy to the economic evaluation of industrial projects. In general, these projects will include investment in the new facilities as well as replacement of old facilities. Concepts of wealth maximization, utility, and risk will be discussed. Financing will be

treated as an integral part of the investment problem.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ISE 5454:

Production Planning and Control

Introduction to the mathematical analysis of various aspects of production planning and control. Among others, this includes topics in inventory control, forecasting, aggregate production planning, production and project scheduling, and line balancing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ISE 5405

Corequisite(s):

ISE 5464:

Queueing Theory

Classic models of queues including M/M/1, M/GI/1, and GI/M/s. Topics in queue length processes, waiting time processes, busy period processes, and traffic processes.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ISE 5414

Corequisite(s):

ISE 5474 (STAT 5474):

Statistical Theory of Quality Control

Development of statistical concepts and theory underlying procedures used in quality control applications. Sampling inspection procedures, the sequential probability ratio test, continuous sampling procedures, process control procedures, and experimental design.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): STAT 5104, STAT 5114

Corequisite(s):

Human Information Processing

An examination of human information reception, information processing, and skilled performance capabilities and limitations in human-machine systems with an emphasis on models and techniques, including psychophysics, signal detection theory, information theory, supervisory control, and decision theory.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ISE 5614 (BMES 5214):

Human Physical Capabilities

Focuses on the modeling, analysis, and evaluation of industrial workplaces with emphasis on the physical demands placed on and the capabilities of workers. Topics covered include: physiology, anthropometry, bioinstrumentation, and biomechanics. Students will learn and apply a range of contemporary analytical and assessment methods. Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ISE 5624:

Human Factors Research Design

Procedures for conducting and analyzing human factors and ergonomics experiments, including fundamentals of research; benefits and limitations of design alternatives; fitting, testing, and assessing statistical models; and data presentation and interpretation. Primary focus on linear regression (simple and multiple) and analysis of variance (single and multiple factor). Pre: Graduate Standing.

Credit Hour(s): 4

Lecture Hour(s): 4

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ISE 5644:

Human Audition and Auditory Display Design

An examination of the human sensory and perceptual experience of sound, with emphasis on relating the capabilities and limitations of

audition to the design of auditory display systems and to noise abatement in hearing conservation efforts. In addition to discussion of human sound reception and sensitivity, human psychological and physiological responses to sound will be covered.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

ISE 5654:

Human Factors System Design

Human factors engineering input into operator-system/product design, development, testing, and evaluation. Emphasis on a systems-oriented and human-centric approach to achieving effective human-machine interfaces. Application of standards, codes and guidelines, as well as empirical methodologies and analytical techniques, to human interface applications and problems. Coverage of human sensory/perceptual capabilities and limitations, with particular emphasis on vision and hearing. Project involving analysis and redesign of an actual device or system with known human factors deficiencies. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

ISE 5674:

System Safety Analysis

The analytical techniques and documentation requirements to provide proper design of equipment and systems and to protect against products liability. Safety concepts, legal concepts, qualitative and quantitative hazard evaluation, hazard classification, system life cycle safety, statistical distributions, software safety analysis, inductive and deductive analysis, Mort, Fault Tree, hands-on projects emphasizing hazard identification and control.

Credit Hour(s): 4

Lecture Hour(s): 4

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

ISE 5694:

Macroergonomics

The optimization of work system design through consideration of relevant personnel, technological, and environmental variables and their interactions. Emphasis is on the theoretical background, research methods, analyses, design, development and applications of work systems and the relationship between macro- and micro-ergonomics.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ISE 5714 (CS 5714):

Usability Engineering

Design and evaluation of effective user interfaces, beginning with principles for designing the product. Development process for user interaction separate from interactive software development.

Development process includes iterative life cycle management, systems analysis, design, usability specifications, design representation techniques, prototyping, formative user-based evaluation. Integrative and cross-disciplinary approach with main emphasis on usability methods and the user interaction development process.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ISE 5734:

Occupational Health and Safety Practicum

Industry-based field instruction and faculty mentoring for advanced learning and practice opportunities relevant to professional ergonomics and safety engineering work. Eighty hours of field practicum experience, to develop and refine knowledge and application of advanced level ergonomics and/or safety engineering practices in a real-world occupational setting. The mentoring component of this course involves regular discussions of field experiences with the instructor and others enrolled in the practicum.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): (ISE 5614 (UG) OR BMES 5214 (UG)) OR ISE 5674 (UG)

Corequisite(s):

ISE 5804:

Fundamentals of Systems Engineering

Fundamental aspects of systems engineering. The role of systems engineering in engineering projects. System life cycle. Systems engineering as an engineering discipline, study and application of technical strategies to realize engineered systems. Basic tools and techniques to identify a need, formulate a problem (e.g., through requirements), develop a system architecture, acquire its building components, integrate them to form the system, verify and validate it, deploy it, and sustain it using a systems approach. Human and social aspects of systems engineering. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ISE 5814:

System Dynamics Modeling of Socio-Technical Systems

Computer-aided approach to systems thinking. Dynamic modeling to make better decisions in complex socio-technical systems. Simulation of dynamic problems arising in complex technological, social, managerial, economic, or ecological systems. Simulation-based policy analysis. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ISE 5834:

Decision Analysis for Engineers

Foundations of decision analysis contextualized for engineering work. Concepts and techniques for framing and modeling engineering problems as decisions that traverse physics by incorporating firms objectives and the personal preferences of the engineer. Formal and informal limitations of decision methods traditionally used in engineering, such as rank matrices. Alternative theories and methods that foster good decisions. Risk assessment and management as inherent to engineering decision making. Sensitivity analysis. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ISE 5844:

Healthcare Systems Engineering and Modeling

Systems modeling and simulation of managerial decision making in complex healthcare settings. Focus on major components of healthcare delivery systems including system resources, system processes, and system outcomes; tools that systems thinking and system dynamics offer for understanding complexities in healthcare systems and for designing policy interventions, examining theoretical advancements as related to modeling healthcare systems. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ISE 5904:

Project and Report

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research

Instruction Type(s): Research

Prerequisite(s):

Corequisite(s):

ISE 5974:

Independent Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Independent Study

Instruction Type(s): Independent Study

Prerequisite(s):

Corequisite(s):

ISE 5984:

Special Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ISE 5994:

Research and Thesis

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research

Instruction Type(s): Research

Prerequisite(s):

Corequisite(s):

ISE 6014:

Proposing Industrial Engineering Research

Processes involved with proposing research in industrial engineering. Methods and approaches to generate effective proposals. Alternative mechanisms involved in identifying and proposing research. Material is examined through several exercises and case studies. Course is intended for second- year doctoral students who have completed the preliminary exam but have not yet defended the proposal. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ISE 6024:

Advanced Topics in Management Systems Engineering

A research-oriented course reviewing the engineering literature in management systems engineering of selected complex systems, structures, and techniques. Industrial, service, governmental, and health care systems will be considered. State-of-the-art topics will be examined to an extent not covered in other courses. May be repeated, with different content, for a maximum of nine credit hours.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

ISE 6054:

Decision Theory

Principles, models, and methods of decision theory. Focus on normative decision theory (how rational agents make decisions), prescriptive aspects (helping people make better decisions) and descriptive aspects

(how people actually make decisions) including utility theory, decision analysis, risk modeling, game theory, multiscale decision theory, analytical hierarchy process, Bayesian networks, and real options theory.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

ISE 6284:

Advanced Topics in Manufacturing Systems Engineering

A research-oriented course reviewing the topics and scientific literature in manufacturing systems analysis, design, and control. State-of-the-art topics may include: manufacturing systems design and control, facility logistics, production planning and scheduling, inventory control, manufacturing systems modeling, and materials management. May be repeated with different content for a maximum of 9 credits.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ISE 5204, ISE 5405, ISE 5424

Corequisite(s):

ISE 6404:

Graph Theory and Network Flows

Graph theoretic concepts and definitions, optimization problems over graphs, and basic results; minimum cost network flow problems (including assignment, transportation, max flow, and shortest-path problems) and associated algorithms with implementation strategies; PERT and CPM; and network design and synthesis problems.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ISE 5405

Corequisite(s):

ISE 6414:

Integer Programming

Modeling with integer variables; enumeration and cutting plane methods; partitioning and relaxation techniques; computational complexity issues; and some special combinatorial optimization problems.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ISE 5405

Corequisite(s):

ISE 6424:

Dynamic Programming

Introduction to the theory, applications, and computational aspects of dynamic programming. Markovian decision processes.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ISE 5405, ISE 5414

Corequisite(s):

ISE 6434:

Scheduling and Sequence Theory

Theory of deterministic scheduling; sequencing of jobs on a single processor; multi-processor problems including flow shop and job shop scheduling; and introduction to the complexity of computations.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ISE 5405

Corequisite(s):

ISE 6444:

Inventory and Operations Management

A fundamental course on mathematical models designed to support production and inventory management, focusing on recent developments inspired by prominent managerial and engineering concerns. These developments include both innovative models and interesting new perspectives on older ones. One central theme is process improvement through reducing leadtimes and improving quality. Models reveal how process parameters affect system performance, and thus estimate the economic benefits of improving them. Another central theme is the coordination of diverse activities, and the key role of inventories as buffers between them.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ISE 5405, ISE 5414

Corequisite(s):

ISE 6464:**Queueing Networks**

Applications of queueing theory results to queueing networks. Topics include reversibility, insensitivity, product forms for queue length processes, and traffic processes including traffic flow within the network.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ISE 5464, ISE 6504

Corequisite(s):

ISE 6474:**Reliability Theory**

An introductory graduate-level examination of mathematical models of failure processes and complex system reliability. Included are existing probability models of component and system failure processes, statistical and experimental methods for estimating failure behavior, and optimization models for supporting design, replacement, and maintenance decisions.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ISE 5414, ISE 5405, STAT 5004

Corequisite(s):

ISE 6494:**Advanced Simulation**

Methodological and theoretical foundation for stochastic simulation and Monte Carlo techniques. A comprehensive discussion of Monte Carlo techniques and algorithms for simulation output analysis, simulation-based optimization, rare-event simulation, variance reduction techniques, and simulation metamodeling methodology. Exposure to contemporary research topics in stochastic modeling and simulation methodology.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): (ISE 5034 OR STAT 5104), (ISE 5414 OR STAT 5434)

Corequisite(s):

ISE 6514:**Advanced Topics in Mathematical Programming**

Decomposition algorithms for large scale linear and nonlinear programs having special structures; algorithmic maps and convergence analysis;

optimality conditions and duality in nonlinear programming; polynomial algorithms for linear programming problems; optimization theory and algorithms for nonsmooth and nonconvex nonlinear programs; calculus of variations and optimal control.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ISE 5406

Corequisite(s):

ISE 6574 (ECE 6774) (AOE 6774) (ME 6574):**Adaptive Control Systems**

NONE

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ISE 6604:**Human Factors in Visual Display Systems**

Quantitative analysis of human visual system capabilities and limitations, and their relationship to the design of visual display components and systems. Emphasis is placed on the measurement and physics of light, visual science data, hardware design, and the use of linear systems theory in display design and evaluation.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ISE 5604, ISE 5605

Corequisite(s):

ISE 6614:**Human Computer Systems**

A survey of human factors procedures used in the design of computer-based systems. Consideration is given to the iterative interface design process, hardware interface design, software interface design, and workplace design.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ISE 5605

Corequisite(s):

ISE 6624:**Advanced Topics in Human Factors**

A research-oriented course reviewing the scientific literature in Human Factors Engineering of selected complex systems. Industrial, civil, transportation, military and computer-based systems will be considered. State-of-the-art topics will be examined to an extent not covered in other courses. May be repeated, with different content.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

ISE 6644:**Cognitive Work and Task Analysis**

Formative, descriptive and normative approaches to work analyses. Comparison between correspondence versus coherence-driven domains. Classes of cognitive systems engineering requirements: work domain, control task, strategies, social organization, and worker competencies. Distinct contributions of different analyses to cognitive systems engineering. Application of cognitive systems engineering analyses: abstraction decomposition space, decision ladder, hierarchical task analysis, information flow map, and skills-rules-knowledge taxonomy. Derivation of design requirements from different analyses for handling unanticipated and routine events in safety critical systems.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ISE 5604, ISE 5605

Corequisite(s):

ISE 6984:**Special Study**

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ISE 7994:**Research and Dissertation**

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research

Instruction Type(s): Research

Prerequisite(s):

Corequisite(s):

MATERIALS SCIENCE AND ENGINEERING

David Clark, Head

Emeriti Faculty: Norman Dowling; Robert Hendricks;

Professors: David Clark; Diana Farkas; Peizhen Lu; Guo Quan Lu; Mitsuhiro Murayama; Gary Pickrell; William Reynolds; Dwight Viehland;

Associate Professors: Alexander Aning; Levon Asryan; Sean Corcoran; Louis Guido; Celine Hin; Abby Whittington;

Assistant Professors: Xianming Bai; Wenjun Cai; Carolina Tallon Galdeano; Hang Yu;

Research Faculty: Jie-Fang Li;

Adjunct Professors: Maureen Julian; Stephen Kampe; Michael Kelley; Chester Van Tyne;

Affiliated Faculty: Romesh Batra; Michael Bortner; Scott Case; Rafael Davalos; Aaron Goldstein; James Heflin; Xiaoting Jia; Blake Johnson; Feng Lin; Herve Marand; Reza Mirzaeifar; Robert Moore; Khai Ngo; Mark Van Dyke; Christopher Williams; Roe Yoon;

Clifton C. Garvin Professor: Romesh Batra;

Associate Professor of Practice: Alan Druschitz; Sean McGinnis; Thomas Staley;

Research Associate Professors: Carlos Suchicital;

Graduate Contact: grandska@vt.edu

MSE Website: <https://mse.vt.edu/>

Graduate Program: <https://mse.vt.edu/Programs/mse-graduate-program.html>

The Department of Materials Science and Engineering awards the M.S. (thesis required), the M.Eng. (non-thesis), and the Ph.D. in materials science and engineering. Candidates for these degrees must hold, or be pursuing, a degree in any branch of engineering, physics, chemistry, geological science, or mathematics. Specialization is available in: 1) structure and properties of crystalline and non-crystalline materials, 2) materials synthesis, processing, and fabrication, 3) theoretical understanding and computer modeling of materials structures, properties and processes, 4) phase transformations, 5) thermodynamics and phase equilibria, 6) diffusion and kinetics of solid state reactions, and 7) mechanical, thermal, electrical, optical, and magnetic property characterization of all material types, and 8) microelectronic and optoelectronic materials.

SPECIAL FACILITIES

403 Specialized laboratories permit research in the following areas:

thermodynamics and phase equilibria; materials corrosion and stability; x-ray diffraction and crystal structure determination; phase transformations, precipitation hardening and diffusion in materials systems; electron (STEM, SEM, ESEM) and optical microscopy; mathematical modeling and computer simulation of structure, defects and processes; surface characterization of materials by ESCA; materials synthesis, processing and fabrication; characterization of residual stresses in materials, fabrication of thin film electronic and optical materials, mechanical alloying of metals; composite material fabrication and characterization; and electrical, optical, thermal, and mechanical property characterization of ceramics, metals, polymers and glasses including composites, thin films, dielectrics and semiconductors. A class 10,000 cleanroom is available for the preparation of microelectronic materials. Additional instructional and research facilities available to MSE personnel include the Kroehling Advanced Materials Foundry located at the Research Compound on Plantation Road and the ICTAS (www.ictas.vt.edu) Nanoscale Fabrication and Characterization Laboratory (www.ncfl.ictas.vt.edu) located at the Virginia Tech Corporate Research Center. The foundry is a state-of-the-art teaching facility with broad capabilities to handle both ferrous and non-ferrous alloys. The NCFL has over \$12 million in state-of-the-art tools including suites devoted to electron and force microscopy, spectroscopy, and other advanced processing and analysis techniques. The Kroehling Foundry is supervised by the VT-FIRE (Foundry Institute for Research and Education) Director, Prof. Alan Druschitz while the NCFL is managed by Prof. William Reynolds. Major research facilities include optical and transmission electron microscopy; an environmental scanning electron microscope; x-ray diffraction equipment including facilities for the measurement of residual stresses in materials; a secondary ion mass spectrometer, a photoelectron emission spectrometer, surface analysis instruments; mechanical testing frames; instruments for measuring the thermal response of materials including thermal expansion, thermal diffusivity, and differential thermal analysis; sputtering, thin film and vacuum deposition equipment; heat treatment and sintering furnaces; a metal melt spinner; mechanical alloying ball mills; dry and hot isostatic presses; electrical and dielectric characterization instruments; polymer processing and characterization equipment; and computer modeling and simulation facilities including access to multimedia and computer visualization facilities.

DEGREES OFFERED

MS Degree

Offered In (Blacksburg)

TOEFL

iBT: (90.0)

GRE

General: Verbal (150.0), Quantitative (155.0), Analytical (4.0)

The M.S. degree requires a thesis. Students with an interest in applied research and development should consider this degree option. Like the M.Eng. degree, the M.S. requires the completion of 30 credit hours of work. Between 6 and 10 of these credit hours are on thesis research (MSE 5994). Most students spend two academic years completing the M.S. program of study. Students are encouraged to read our Graduate Student Manual, which can be found on our website, for more detailed information about our degree requirements.

MEng Degree

Offered In (Blacksburg)

TOEFL

iBT: (90.0)

GRE

General: Verbal (150.0), Quantitative (155.0), Analytical (4.0)

The M.Eng. is a non-thesis degree obtained through course work and a project that focuses on an industrial problem or critical literature review. Students with a baccalaureate degree who desire a professional-oriented master's degree and advanced undergraduate students who wish to supplement their background with additional course work are encouraged to consider the M.Eng. degree. A total of 30 credit hours are required for this degree; between 3 and 6 of these hours are project work (MSE 5904), the remainder are course credits. Students typically complete this degree in 12 to 18 months. Students are encouraged to read our Graduate Student Manual, which can be found on our website, for more detailed information about our degree requirements.

PhD Degree

Offered In (Blacksburg)

TOEFL

iBT: (90.0)

GRE

General: Verbal (150.0), Quantitative (155.0), Analytical (4.0)

The Ph.D. degree is intended for exceptional students who have a strong interest in scholarship and a desire to do independent research. This degree program is designed to be flexible to meet the broad interests of students and faculty. General requirements for the degree are those of the College of Engineering. A master's degree is neither a prerequisite nor a requirement. However, many Ph.D. students complete the requirements for a master's degree while working toward the Ph.D. degree. The Ph.D. requires the completion of 90 credit hours of work. Students are encouraged to read our Graduate Student Manual, which can be found on our website, for more detailed information about our degree requirements.

GRADUATE COURSES (MSE)

MSE 5004:

Materials Science and Engineering Graduate Fundamentals

Overview of MSE program requirements; Honor code and ethics; student responsibilities; campus services; student organizations; data and time management; thesis and dissertation styles; student-mentor relationships; career building; research techniques; and communication strategies for faculty, staff, and peers. Pass/Fail only. Pre: Graduate standing.

Credit Hour(s): 1

Lecture Hour(s): 1

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

MSE 5014 (CHE 5014) (CHEM 5014):

Presentation Skills

Methods and style to make effective technical and nontechnical presentations including blackboard presentations, overhead presentations, slide presentations, and research posters. Video presentations with critiques.

Credit Hour(s): 1

Lecture Hour(s): 1

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

MSE 5015:

Materials Science and Engineering Seminar

Materials Science and Engineering students are required to participate in Materials Science and Engineering Seminar during every semester of their residency. Masters of Science or Engineering students must present one seminar during the course of their studies; PhD students must present two seminars during their tenure. Provides training in the organization, preparation, and presentation of technical information. Pre: Graduate standing in MSE.

Credit Hour(s): 1

Lecture Hour(s): 1

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

MSE 5016:

Materials Science and Engineering Seminar

Materials Science and Engineering students are required to participate in Materials Science and Engineering Seminar during every semester of their residency. Masters of Science or Engineering students must present one seminar during the course of their studies; PhD students must present two seminars during their tenure. Provides training in the organization, preparation, and presentation of technical information.

Credit Hour(s): 1

Lecture Hour(s): 1

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

MSE 5024:

Mathematical Methods in Materials Research

Analytical and numerical techniques applied to problems in materials science. Translating physical information into a mathematical model, obtaining a solution by selecting and applying suitable mathematical methods, applying modern computing tools, and interpreting the meaning and implication of the mathematical solution in terms of the appropriate theories of materials science. An undergraduate science or engineering degree and mathematics through differential equations required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

MSE 5034:

Structure and Properties of Materials

An introduction to descriptions of the structure of matter and materials properties. Bravais lattices, Miller indices, reciprocal space, stereographic projections, symmetry and crystal defects. Matrix methods for calculating crystal directions, lengths and angles. Tensor descriptions of properties. Diffraction and scattering from crystals. Undergraduate physical sciences or engineering degree is required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

MSE 5044:

Powder Processing

Processing methods associated with making consolidated components from powders. Preparation, blending, and compaction of metallic, ceramic, and polymeric powders. Solid-state and liquid-phase sintering. Laser and microwave sintering.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

MSE 5054:

Material systems with particular emphasis on alloys. Thermodynamic relationships. Experimental and computational methods for the determination of the thermodynamic properties of alloys. Applications in alloying, heterogeneous reactions, and the thermodynamics of surfaces.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): MSE 4034

Corequisite(s):

MSE 5064:

Diffusion and Kinetics

Theories of diffusion mechanisms in solids. Solutions of governing differential diffusion equations. Classical nucleation theory, spinodal decomposition, diffusion-controlled growth kinetics, overall transformation kinetics.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): MSE 5024, MSE 5054

Corequisite(s):

MSE 5114:

Introduction to Materials Characterization

Introduction to techniques used to characterize material structure and chemistry. Physical principles behind surface and microanalysis techniques and the information various techniques provide. X-ray, electron, ion, vibrational, and absorption spectroscopy and optical, electron, and acoustic microscopy. Undergraduate degree in physical sciences or engineering is required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

MSE 5124:

Materials Optimization Through Designed Experiments

Methods of analysis of variation in materials systems, in manufacturing or R&D, through the use of statistical methods including experimental design techniques (DOE) with instructional examples related to Materials Science and Engineering. Undergraduate physical sciences or engineering degree is required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

MSE 5134:

Transmission Electron Microscopy

Transmission electron microscopy for research applications in the physical sciences. Theories of electron diffraction, imaging and spectroscopy on transmission and scanning transmission electron microscopes (TEM, STEM). Interpretation of electron diffraction patterns, images and spectra.

Credit Hour(s): 3

Lecture Hour(s): 2

Instruction Type(s): Lab, Lecture, VB, Online Lecture

Instruction Type(s): Lab, Lecture, VB, Online Lecture

Prerequisite(s): MSE 5334

Corequisite(s):

MSE 5144 (ESM 5144):

Deformation and Fracture of Materials

Deformation and fracture of engineering materials is considered in the context of solid mechanics and engineering methods for predicting strength and life. Topics include plasticity, failure criteria, fracture mechanics, crack growth, strain-based fatigue, and creep.

Microstructure-property relationships are discussed. Laboratory demonstrations of behavior in mechanical tests are included. Partially duplicates material in ESM 4024 and both should not be taken.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

MSE 5154:

Processing Science In Advanced Manufacturing

Processing science. State-of-the-art manufacturing technologies. Incorporation of phase transformation, diffusion, and kinetics concepts with materials processing. Additive manufacturing (3D printing) of metals, ceramics, and polymers. Composite processing, semiconductor manufacturing, thin film processing. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

406 Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

MSE 5164:

Principles of Corrosion and Electrochemical Processes

Introduction to the principles of materials corrosion and corrosion protection. Topics include: thermodynamics of materials corrosion, including potential-pH (Pourbaix) diagrams, kinetics of corrosion reactions and mixed potential theory, types of corrosion (uniform, galvanic, crevice, pitting, fatigue, stress corrosion cracking, intergranular, and hydrogen embrittlement), material/ environmental factors that promote or prevent the various types of corrosion, and methods and techniques of corrosion testing. Undergraduate physical sciences or engineering degree is required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

MSE 5174:

Advanced Physical Ceramics

Characteristics of vitreous and crystalline inorganic nonmetallic materials. Application and discussion of effects of composition and microstructure on thermal, mechanical, optical, electrical, and magnetic properties of ceramic products.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

MSE 5200 (ECE 5200):

Semiconductor Alloys and Heterostructures

Advanced treatment of semiconductor materials with an emphasis on binary compounds, ternary and quaternary alloys, and strained-layer structures. Topics include crystal structure; lattice vibrations and phonons; energy band structure; equilibrium and non-equilibrium carrier distributions; electron and hole transport via diffusion and drift; and carrier generation and recombination mechanisms. Graduate standing required in the College of Engineering or College of Science.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): MSE 3204 (UG) OR PHYS 3455 (UG) OR ECE 4214 (UG) OR MSE 3204 OR PHYS 3455 OR ECE 4214

Corequisite(s):

MSE 5234:

Introduction to the Materials Science of Surfaces and Interfaces

Fundamental and applied aspects of surfaces. Solid/solid, solid/liquid, and solid/vapor interfaces. Their structure and defects, thermodynamics, reactivity, electronic and mechanical properties. Applications depend upon class interests, but can include microelectronics, soils, catalysis, colloids, composites, environment-sensitive mechanical behavior, UHV single crystal studies, materials durability and surface bioactivity. Prerequisite: Undergraduate degree in physical sciences or engineering.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

MSE 5304:

Contemporary Topics in Materials Science and Engineering

Contemporary topics in materials research selected from technical literature or recent faculty research initiatives. Topics stress the development of fundamental concepts and/or technologies of current interest to materials science and engineering. May be repeated for credit with different content for a maximum of 9 credit hours. Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

MSE 5334:

Advanced Applied Materials Analysis

Instrumentation, fundamentals, and practical application of characterization techniques. Scanning and Transmission Electron Microscopy, Energy Dispersive X-ray Spectrometry, Focused Ion Beam tools, Atomic Force Microscopy. Practical aspects of theory and operation of materials characterization equipment. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 2

Instruction Type(s): Lab, Lecture, VB, Online Lecture

Instruction Type(s): Lab, Lecture, VB, Online Lecture

Prerequisite(s):

Corequisite(s):

MSE 5384G:

Advanced Nuclear Materials

Materials for nuclear applications with emphasis on fission reactors. Fundamental radiation effects on materials; material properties relevant to structural, moderator, reflector, blanket, coolant, control related structural systems. Pre-requisite: Graduate Standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

MSE 5394:

Advanced Molecular Dynamics Simulation

Advanced molecular dynamics simulation method. Fundamental molecular dynamics principles, algorithms and components (atomic structure, periodic boundary conditions, interatomic potentials, equations of motion of atoms, statistical ensembles, integration of equations of motion). Numerical integration of equations of motion. Simulations of the time evolution of atoms, particles, or molecules under static or varying thermodynamic conditions and external loads. Connection between atom trajectories and evolution of the physical property of the simulation system with statistical mechanics principles. Hands-on case studies using LAMMPS (Large-scale Atomic/Molecular Massively Parallel Simulator) molecular dynamics simulation package. Analysis and interpretation of simulation results. Prior knowledge of a programming language such as Fortran, C, C++, Matlab, Mathematica, Python, Java is highly recommended. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

MSE 5504 (NSEG 5504):

Radiation Effects on Metals and Alloys

Radiation effects on metals and alloys. Interaction between particles and atoms, radiation damage, displacement of atoms, diffusion of point defects, radiation-induced segregation, phase instability, transmutation products, irradiated material mechanical properties. Pre: Graduate Standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): MSE 4554, MSE 4564, ESM 4024

Corequisite(s):

MSE 5574G:

Advanced Biomaterials

Materials for medical applications. Basic material types and properties, functional uses of materials in medical applications, and tissue response mechanisms. Integrated design issues of multicomponent material design in prosthetic devices for hard and soft tissues, orthopedics, cardiovascular, and drug delivery applications. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

MSE 5584:

Biomimetic Material Design

The application of the structure property relationships in biological materials such as wood, bone, shells, spider silk, connective tissue, blood vessels, and jellyfish as a means to design new materials. Proteins and polysaccharides, biosynthesis and assembly, biomineralization, hierarchical organization. Introduction to tissue engineering and regenerative medicine. Life cycle, environmental aspects of biofabrication. Structural characterization of biological materials. Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

MSE 5614:

Advanced Nanomaterials

Synthesis of 0-dimensional nanoparticles, 1-dimensional nanotubes, nanowires, and nanorods; 2-dimensional nanoribbons and nanofilms, and specialized nano-features on substrates. Characterization of nanomaterials. Processing into higher order dimensions. Chemical, physical, mechanical, and electrical properties of nanomaterials. Application of nanomaterials.

Credit Hour(s): 3

408 Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): MSE 5054

Corequisite(s):

MSE 5904:

Project and Report

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research, Online Research

Instruction Type(s): Research, Online Research

Prerequisite(s):

Corequisite(s):

MSE 5974:

Independent Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Independent Study

Instruction Type(s): Independent Study

Prerequisite(s):

Corequisite(s):

MSE 5984:

Special Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

MSE 5994:

Research And Thesis

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research

Instruction Type(s): Research

Prerequisite(s):

Corequisite(s):

MSE 6214:

Semiconductor Nanostructures

In-depth self-consistent coverage of semiconductor nanostructures with an emphasis on low-dimensional heterostructures, such as quantum wells, quantum wires, quantum dots, and superlattices. Electronic and optical properties of nanostructures; tunneling in nanostructures; quantum phenomena in nanostructures in electric and magnetic fields; and two dimensional electron gas.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): MSE 5200

Corequisite(s):

MSE 7994:

Research and Dissertation

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research

Instruction Type(s): Research

Prerequisite(s):

Corequisite(s):

MECHANICAL ENGINEERING

Azim Eskandarian, Head

Emeriti Faculty: James Mahan;

Professors: Mehdi Ahmadian; Pinhas Ben-Tzvi; Ricardo Burdisso; Thomas Diller; Azim Eskandarian; Christopher Fuller; Alireza Haghghat; Andrew Kurdila; Brian Lattimer; Alexander Leonessa; John Lesko; Roop Mahajan; Rolf Mueller; Douglas Nelson; Wing Fai Ng; Mark Paul; Ranga Pitchumani; Rui Qiao; Michael Roan; Corina Sandu; Chang Min Son; Danesh Tafti; Saied Taheri; Christopher Williams; Jinsuo Zhang; Lei Zuo; Michael von Spakovsky;

Associate Professors: Bahareh Behkam; Jan Helge Bohn; Jonathan Boreyko; Jiangtao Cheng; Clinton Dancey; Michael Ellis; John Ferris; Warren Hardy; Celine Hin; Scott Huxtable; Mary Kasarda; Kevin Kochersberger; Yang Liu; Amrinder Nain; Steve Southward; Pablo Tarazaga; Brian Vick; Robert West; Alfred Wicks;

Assistant Professors: Pinar Acar; Kaveh Akbari Hamed; Alan Asbeck; Oumar Barry; Michael Bartlett; Sohan Kale; Erik Komendera; Ling Li; Zheng Li; Dylan Losey; Joseph Meadows; Reza Mirzaeifar; Juliana Pacheco Duarte; John Palmore; Shima Shahab; Alexandrina Untaroiu;

Research Faculty: Ronald Kennedy;

Affiliated Faculty: Nicole Abaid; Masoud Agah; Diana Bairaktarova; Romesh Batra; Brenda Brand; Stefano Brizzolara; Scott Case; Shengfeng Cheng; Rafael

Davalos; Raffaella De Vita; William Devenport; David Dillard; Stefan Duma;
Hampton Gabler; Jacob Grohs; Serkan Gugercin; Andrea L'Afflitto; Kevin Lowe;
Vinh Nguyen; Maury Nussbaum; Robin Queen; John Robertson; Shane Ross;
Rodrigo Sarlo; Joseph Schetz; Gary Seidel; Maryam Shakiba; John Socha; Mark
Stremler; Costin Untaroiu; Mark Van Dyke; Craig Woolsey; Roe Yoon;

John R. Jones III Faculty Fellow: Rui Qiao; Pablo Tarazaga;

J. Bernard Jones Chair: Mehdi Ahmadian;

Samuel Langley Distinguished Professor of Engineering: Christopher Fuller;

Samuel Herrick Professor of Biomedical Engineering and Mechanics:

Hampton Gabler;

W. Martin Johnson Professor: Andrew Kurdila;

Lewis A. Hester Chair Professor: Roop Mahajan;

Christopher C. Kraft Endowed Professor: Wing Fai Ng;

George R. Goodson Professor: Ranga Pitchumani;

Associate Professor of Practice: Robin Ott; Mark Pierson; Shivakumar
Ranganathan; Linda Vick;

Robert E. Hord, Jr. Professorship of Mechanical Engineering: Corina Sandu;
Lei Zuo; Michael von Spakovsky;

William S. Cross Professor: Danesh Tafti;

L.S. Randolph Professorship of Mechanical Engineering: Christopher Williams;

Clifton C. Garvin Professor: Romesh Batra;

L. Preston Wade Professor: Rafael Davalos;

Nicholas and Rebecca Des Champs Chair in Mechanical Engineering: Azim
Eskandarian;

Reynolds Metals Professor: Scott Case;

Virginia Microelectronics Consortium Professor: Masoud Agah;

Harry C. Wyatt Professor: Stefan Duma;

Fred D. Durham Endowed Chair: Joseph Schetz;

H.G. Prillaman Professor: Maury Nussbaum;

Assistant Professor of Practice: Ry Long;

Adhesive and Sealant Science Professor: David Dillard;

Rolls-Royce Commonwealth Professor: Chang Min Son;

Nicholas T. Camicia Professor: Roe Yoon;

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Graduate Academic Advisor, NCR: arjones@vt.edu

ME Department Site: <http://www.me.vt.edu>

ME Graduate Studies Guide: http://www.me.vt.edu/wp-content/uploads/2019/10/2019-2020_MEDept_GraduateProgramsPolicy_Oct2019.pdf

ME Research Centers & Labs: <http://www.me.vt.edu/research/>

Bursar's Office: <http://www.bursar.vt.edu>

University Scholarships and Financial Aid: <http://www.finaid.vt.edu/>

Timetable of Classes:

https://banweb.banner.vt.edu/ssb/prod/HZSKVTSC.P_DispRequest

Medical Insurance: <http://risk.controller.vt.edu/studentmedicalinsurance.html>

Fellowships and Scholarships: <https://graduateschool.vt.edu/funding.html>

Dates & Deadlines: <http://registrar.vt.edu/dates-deadlines-accordion.html>

College of Engineering: <http://www.eng.vt.edu/>

Housing: <http://www.housing.vt.edu/>

New Student Checklist: <http://graduateschool.vt.edu/admissions/getting-started-as-a-student.html>

Office of Veterans Services: <https://www.veterans.vt.edu/>

Historical Timetable of Classes:

https://banweb.banner.vt.edu/ssb/prod/HZSKVTSC.P_DispHistorical

One Campus: <https://onecampus.vt.edu/>

The graduate programs in the ME Department at Virginia Tech provide quality mechanical engineering education through innovative research, faculty expertise, and practices that further expand and enhance students' abilities in communication and problem solving, service and leadership within their profession, industry, and higher education. The Department of Mechanical Engineering offers advanced study and research opportunities leading to PhD, MS, and MENG degrees. Each student, in cooperation with his or her advisory committee, develops a plan of study including research and course selection appropriate to the student's individual interests and research needs. Courses include (but are not limited to) topics on: acoustics, active materials/smart structures, automatic controls, biomedical topics, combustion, finite elements in machine design, fluid dynamics, fuel cell systems, heat transfer, nanotechnology, nuclear engineering, propulsion, rotor dynamics, thermodynamics, turbomachinery and vibrations. Students often take courses from outside the department in mathematics, statistics, and many other disciplines. The Mechanical Engineering Department also has international collaborations with the Technische Universität Darmstadt, as well as Thapar institute of Engineering and Technology in India. VT undergraduates with high GPAs can also apply for the Accelerated Undergraduate/Graduate degree program. A Nuclear Engineering Graduate Certificate is available for students to pursue, in conjunction with their graduate degree program.

SPECIAL FACILITIES

To facilitate research, the department has specialized laboratories such as an anechoic chamber, a combustion laboratory, a computer-aided design laboratory, a fuel cells systems laboratory, a gas turbine test cell, impact biomechanics laboratory, a laser dynamics imaging laboratory, a mechatronics laboratory, a rapid prototyping laboratory, a reverberation room, and a thermal radiation laboratory among others. Many of these laboratories support one or more of the seven research centers and the more than 30 laboratory groups within the department. A list of centers and research groups are listed below, including links to the web sites if available.

MultiScale Mechanics of Advanced Materials Laboratory

Director: Prof. Reza Mirzaeifar
The MultiScale Mechanics of Advanced Materials Laboratory (MultiSMARt) group uses a wide range of theoretical, computational and experimental methods at different length scales to study the mechanics of various advanced materials including shape memory alloys, carbon-based materials, biological and bio-

inspired materials, composites and soft materials. Please see the Research page for more details about the active research topics in MultiSMART.

Nuclear Materials and Fuel Cycle Center

Director: Prof. Jinsuo Zhang
The Nuclear Materials and Fuel Cycle Center (NMFC) focuses on three research topics: material degradation, nuclear coolant chemistry and purification and electrochemical separation for nuclear applications. Degradation of structural materials including fuel cladding has been recognized as one of the key factors that affect the performance of a nuclear reactor, especially for Gen.IV advanced reactors. The material degradation can be due to the corrosive property of a nuclear coolant such as liquid metal, molten salt and high temperature water or the chemical reactions between different materials such as fuel cladding chemical interactions (FCCI). Electrochemical separation has been found to be an effective method to separate nuclear materials from spent nuclear fuels and purify advanced coolant such as molten salts and liquid metals. Specifically, the center focuses on : 1) Nuclear Materials compatibility (materials corrosion/degradation), 2) Nuclear Fuel Cycle Technology; 3) Electrochemical Separation; 4) Nuclear Safeguards and nonproliferation; and 5) Advanced Coolant (molten salt, liquid metal) chemistry and chemistry control
The Center is equipped with following facilities/equipment:1) Flow loops for materials corrosion and coolant chemistry: Molten salt loop, high-temperature water loop, high temperature steam loop and stress corrosion cracking loop2) Glovebox systems for both radioactive and non-radioactive materials 3) Autoclave systems for in-situ corrosion measurements (molten salt, high-temperature/pressure water, liquid metal)4) High-temperature electrochemical cells for molten salt/liquid metal corrosion and chemistry5) Low-temperature electrochemical cells for water corrosion and chemistry
Website:

<http://www.me.vt.edu/research/laboratories/nmfc/>

Abilities, Creativity, and Ethics in Design Laboratory

Director: Diana Bairaktarova
Through real-world engineering applications, the Abilities, Creativity, and Ethics in Design Laboratory (ACE(D) Lab) experiential learning research crosses disciplines including engineering, psychology and the learning sciences, as we uncover how individual performance is influenced by abilities, personal interests and direct manipulation of physical and virtual objects. Led by Dr. Diana Bairaktarova, the ACE(D) Lab at Virginia Tech is dedicated to engineering and design education research and the engineering learner. Our interdisciplinary research focuses on the following three lines of inquiry:1. Using innovative technologies to study novel user interfaces, virtual and augmented learning and working environments that encompass human aspects at the cognitive, eye-tracking and sensory-motor levels.2. Investigating the role of individual aptitudes and abilities in performing and learning engineering through psychometric instruments and psychological interventions.3. Adopting design thinking

as a philosophy (inspiration, ideation, and quick prototyping) to investigate user-centered design, empathic design and design for social innovation.

Acoustics Signal Processing and Immersive Reality Laboratory

Director: Prof. Michael Roan
Acoustics Signal Processing and Immersive Reality Lab (ASPIRe) mission is to explore all aspects of immersive reality. Recent innovations such as Oculus Rift have made tremendous strides toward bringing the visual component of immersion to a wide audience. A major part of our work is making realistic 3D audio for gaming, live performance, distance learning, and cinema a reality. Other major thrusts include development of signal processing algorithms for anomaly detection applied to mechanical systems. Previous work of the lab includes automated bearing fault detection, detection of anomalies in synthetic aperture radar, and automated detection of faulty parts on high-speed assembly lines. We are dedicated to creating an environment of inclusion, where everyone's voice is heard, and ideas flow freely. The main goal of the lab is to provide students with an extensive toolbox of highly-desired skills, high-impact publications, specialized technical experience and to have a lot of fun doing it!

Adhesion Mechanics Laboratory

Director: David Dillard
The Adhesion Mechanics Laboratory focuses on characterizing the integrity, performance, and durability of adhesive bonds, elastomers, membranes, and other polymeric material systems. Fracture mechanics and viscoelasticity principles are applied for the experimental characterization, as well as the analytical and numerical analyses, of bonded systems. Ongoing and recent research activities have involved sponsorship from government and industrial entities, including in the aerospace, automotive, microelectronic, and consumer product areas. Materials studied include structural and pressure sensitive adhesives, fuel cell membranes, hydrogels, additive manufactured materials, and bonded wood composites.

Advanced Combustion and Energy Laboratory

Director: Prof. Joseph Meadows
The Advanced Combustion and Energy Laboratory focuses on the research and development of next-generation combustion technologies for propulsion and power generating applications.

Advanced Control Systems Lab

Director: Andrea L'Afflitto
The Advanced Control Systems Lab (ACSL) at Virginia Tech focusses on the design of new guidance and control techniques for autonomous systems such as unmanned aerial vehicles (UAVs), robotic arms, and unmanned ground vehicles (UGVs). With its 18,000 cubic feet test cage, 3D printers, and state-of-the-art computers, ACSL provides a unique learning experience to its numerous graduate and undergraduate student and trains them to be highly competitive in the modern, fast-paced job market. Additional details about the lab director, Dr. L'Afflitto, and ACSL can be found at <http://lafflitto.com>.

Advanced Materials and Technologies Laboratory

Director: Prof. Ranga Pitchumani The Advanced Materials and Technologies Laboratory (AMTL) focuses on research, development and demonstration in advancing the state-of-the-art in materials processing and manufacturing; energy systems; energy/water nexus; energy storage; and micro and nanotechnologies.

Advanced Propulsion and Power Laboratory

Co-Directors: Profs. Todd Lowe & Wing Ng Affiliated Faculty: Profs. Colin Adams, Joseph Meadows, Joseph Schetz, Changmin Son, Alexandrina Untaroiu, and Greg Young The Virginia Tech Advanced Propulsion and Power Laboratory (APPL) comprises state-of-the-art experimental facilities dedicated to the study of jet propulsion, propulsion integration, and the internal design of gas turbine engines and other propulsion and power systems. This laboratory spans two sites adjacent to both the Virginia Tech campus and the Virginia Tech Montgomery Executive Airport. The mission of APPL is to support and facilitate research and research education with a pathway for technology maturation and transition for aviation, defense, and power generation sponsors in government and industry. The goals of the laboratory include (1) providing laboratory facilities and an environment for collaboration among faculty, students, and researchers on turbomachinery, propulsion aerodynamics, hypersonics, and rocketry research, (2) educating students for research and development in aviation, defense, and power generation fields (3) providing value to sponsors, leading to high impact publication of research findings, and (4) exhibiting an active presence in the greater propulsion and power technical community that enhances the laboratory reputation through conference participation and professional leadership. Advanced Power and Propulsion Laboratory (APPL) is a state-of-the-art, leading-edge facility dedicated to the study of jet propulsion and the internal design of gas turbine engines and other propulsion and power systems.

Advanced Research Computing

Director: Prof. Terry Herdman Advanced Research Computing (ARC) provides centralized support for research computing by building, operating and promoting the use of advanced cyberinfrastructure at Virginia Tech. ARC seeks to maximize research productivity at Virginia Tech through interdisciplinary collaborations that connect researchers to new opportunities in computing and data driven research. ARC also provides a competitive advantage to VT research in obtaining external research support. Towards this end, ARC delivers a comprehensive ecosystem consisting of advanced computational systems, large-scale data storage, visualization facilities, software, and consulting services. By fostering strategic partnerships, ARC serves to cultivate advanced computing infrastructure as a platform for collaboration and helps secure the position of Virginia Tech as a leader in education, innovation, and research. ARC offers and hosts conferences, seminars, scientific computing courses and lectures catering to all levels of academia while creating a more socially inclusive environment and broadening the

collective insight of the field through increased diversity.

Advanced STRuctures and Optimization (ASTRO) Lab

Director: Prof. Pinar Acar Advanced STRuctures and Optimization (ASTRO) Lab We are interested in advanced computational problems (multi-scale modeling, design, optimization, uncertainty quantification, model reduction) for a large variety of structures (metals, metallic alloys, composites) in different length scales (molecular, meso and macro scales).

Advanced Vehicle Dynamics Laboratory

Director: Prof. Mehdi Ahmadian The Advanced Vehicle Dynamics Lab (AVDL), part of the Center for Vehicle Systems and Safety (CVeSS) at Virginia Tech, was established in 1995 by Dr. Mehdi Ahmadian, J. Bernard Jones Chair Professor of Mechanical Engineering. AVDL provides innovative and cost-effective solutions in advanced vehicle technologies toward improving the sponsors' products and market share, creates a productive environment for educating both graduate and undergraduate students, and conducts state-of-the-art research in the area of vehicle dynamics. The lab currently has several research scientists, visiting scholars, graduate research assistants, and undergraduate students. AVDL has obtained more than 10 million dollars of funded research in vehicle dynamics and control.

Applied Autonomy and Mechatronics Research Laboratory

Director: Prof. Al Wicks The Applied Autonomy and Mechatronics Research Laboratory focuses on creating practical engineering solutions by integrating sensors and microcontrollers in to military and medical applications.

Assistive Robotics Laboratory

Director: Prof. Alan Asbeck The Assistive Robotics Laboratory (ARLab) focuses on developing human-assistance devices and on understanding how to make them work most effectively with the body. The goal is to help people to regain capabilities they have lost, or enable people to perform feats that were not previously possible.

Autonomous Systems and Intelligent Machines Laboratory

Director: Prof. Azim Eskandarian The Autonomous Systems and Intelligent Machines Laboratory (ASIM) is established to conduct research in controlling multiple mechanical/electromechanical systems (robots, vehicles, mechanisms) to operate either autonomously or semi-autonomously in coordination with humans. We take advantage of intelligence created by a host of sensors, connectivity through communications, and advanced controls and learning algorithms. We also attempt to learn from biological systems and human brain functions, through signal processing, to mimic intelligent motor control. Our current focus is on coordinated control of communication enabled mobile robots and vehicles with various on-board sensors which are linked to other robots/vehicles and surrounding environment. Our mobile robots emulate autonomous and connected vehicles with communications of vehicle-to-vehicle (V2V), Vehicle-to-Infrastructure (V2X) and Vehicle to

other entities such as road users, pedestrians, bicyclists, etc. We are developing and evaluating hybrid hierarchical control algorithms for autonomous driving, platooning, merging, and several other dynamic coordinated functions of intelligent vehicles and robots in complex environments. A second area of focus is on driving safety dealing with Advanced Driver Assistance Systems (ADAS) and active safety systems. We seek to understand driver cognitive perception-response abilities through human brain and physiological monitoring and modeling motor/control actions. The in-depth understanding of the driver's perception-response to external stimuli enables development of more coherent ADAS, thus leading to more intelligent vehicles. These vehicles better interact with drivers and support driving functions automatically as a continuously supporting co-pilot. Driving, due to its complexity and involvement of continuous sensing, decision making, and perception-response tasks, is a suitable test bed for human brain monitoring and investigation. However, our research discoveries would be similarly useful and applicable to other brain-controlled tasks and functions such as limb control, patient rehabilitation, or brain control of machines.

Batra Computational Mechanics Laboratory

Director: Romesh BatraThe Batra Computational Mechanics Laboratory at Virginia Tech specializes in the development of mathematical and computational models of nonlinear and multi-physics phenomena that involve thermal, mechanical, viscous and electrical effects in elastic (e.g., rubber like, and biological materials), elastic-plastic (e.g., ceramics, metals, polymers), and thermo-visco-elasto-plastic materials under extreme loads such as those caused by improvised explosive devices and slamming of a boat into water (i.e., fluid-structure interaction). The group studies the initiation and progression of damage and failure in monolithic and composites including sandwich structures with fiber-reinforced

Center for Bioinspired Science & Technology

Director: Prof. Rolf MuellerThe Center for Bioinspired Science & Technology (BIST) is an interdisciplinary research center at Virginia Tech that is dedicated to the study of biological function from an engineering perspective. The goal of the research is to create novel technology based on insights obtained from biological model systems that continue to outperform their man-made peers. Within the BIST Center, Dr. Mueller's team uses a combination of soft-robotics and deep learning to understand and replicate the function of the biosonar system in bats. If successful, this research could lead to new technologies for realizing autonomy in complex natural environments.

Center for Energy Harvesting Materials and Systems

Director: Prof. Lei ZuoThe Center for Energy Harvesting Materials and Systems (CEHMS) is a consortium of major research universities, industry partners and commercial and government organizations. CEHMS is sponsored through the National Science Foundation Industry/University Cooperative Research Centers (I/UCRC) program

with the aim of developing interdisciplinary strengths in science and technology to provide integrated solutions for challenging energy harvesting, storage and application problems.

Center for Energy Systems Research

Director: Prof. Michael von SpakovskyThe mission of the Center for Energy Systems Research (CESR) is to conduct both fundamental and applied research into all aspects of energy systems and their components whether for transportation, stationary, or portable applications. Single disciplinary and multidisciplinary research includes analytical, numerical, and experimental modeling from the atomistic to the large-scale system levels. In addition, faculty develop and teach energy-based courses both at the undergraduate and graduate levels as well as short courses on various topics such as, for example, non-equilibrium thermodynamics, fuel cells, building energy systems, hybrid electric vehicles, etc.

Center for Injury Biomechanics - Virginia Tech/Wake Forest

Director: Prof. Warren HardyThe Center for Injury Biomechanics (CIB) performs research investigating human tolerance to impact loading. The application of this research includes automobile safety, military restraints, and sports biomechanics.

Center for Marine Robotics

Director: Stefano BrizzolaraThe Center for Marine Robotics at Virginia Tech is an interdisciplinary organization that spans multiple academic departments including the Bradley Department of Electrical and Computer Engineering and the Kevin T. Crofton Department of Aerospace and Ocean Engineering. Accomplishments range from advances in fundamental theory to novel marine robotic solutions.

Center for Tire Research

Director: Prof. Saied TaheriThe Center for Tire Research (CenTiRe) is an NSF Industry/University Cooperative Research Center (I/UCRC) which focuses on supporting a research program in tire materials, modeling, manufacturing, and testing combined with rubber material prototyping and testing, and parallel computing and dynamic simulation capabilities. Our two world-class university sites, Virginia Tech and the University of Akron, have the expertise and facilities to perform the research requested by our industry members. They also serve as an excellent training ground for students to enter industry. Our industry members are at core of the Center through involvement in the Industry Advisory Board, setting the operating procedures and direction of research to be carried out by the Center. These members come from the tire, vehicle, materials, and testing industries. They cooperatively propose and select the research to be conducted, fund the work through their combined annual membership fees, mentor the ongoing work, and share in the results. This process facilitates the transfer of technology from the university to the industry members, as well as linking the companies to graduate students as potential interns and future employees. Research already conducted by CenTiRe for our members

has spanned the range from molecular level filler/polymer interaction, improved compounding, material characterization, durability testing and simulation, tire/road/ice interactions, radiated noise, intelligent tire, and tire/vehicle/road surface simulations. Many of our graduated students who gained experience in these Center-funded projects are now working in our member companies. CentiRe looks to continue to grow, both in its industry memberships and by adding universities with expertise that complement our already existing capabilities to better perform tire and tire-related research for our members.

Center for Unmanned Aircraft Systems

Co-Directors: Prof. Craig Woolsey & Kevin Kochersberger
The Center for Unmanned Aircraft Systems (C-UAS) is an Industry/University Cooperative Research Center whose members include Brigham Young University, the University of Colorado at Boulder, Virginia Tech, and the University of Michigan. The center is the only National Science Foundation-funded unmanned aircraft research center to provide innovative solutions to key technical challenges and superb training for future leaders in the unmanned aircraft systems industry.

Center for Vehicle Systems & Safety

Director: Prof. Mehdi Ahmadian
The Center for Vehicle Systems and Safety (CVeSS) at Virginia Tech was established in 2004 by Dr. Mehdi Ahmadian, J. Bernard Jones Chair Professor of Mechanical Engineering and Director of CVeSS. The Center consists of two laboratories: Advanced Vehicle Dynamics Laboratory (AVDL, established 1995) and Railway Technologies Laboratory (RTL, established 2004). The center is served by a large number of faculty members, research scientists, visiting scholars, graduate students, and undergraduate students, who support a diverse portfolio of projects. CVeSS conducts state-of-the-art fundamental, scientific, and experimental research in the area of road, rail and marine vehicles. It provides innovative and cost-effective solutions in our area of expertise to improve our sponsors' technologies, products and market share, and creates a productive environment for educating students to better serve their future employers.

Cheng Computational and Theoretical Soft Matter Laboratory

Director: Prof. Shengfeng Cheng
The Cheng Computational and Theoretical Soft Matter Laboratory group is mainly interested in soft condensed matter systems, including both biological and synthetic polymers, nanoparticles, and nanocomposites. Researchers in the group use molecular dynamics simulations and theoretical models based on statistical mechanics to study phenomena including supramolecular/supramacromolecular self-assembly, nanoparticle self-assembly, evaporation, wetting, adhesion, friction, and crumpling phenomena.

Collaborative Robotics Lab

Director: Prof. Dylan Losey
Welcome to the Collaborative Robotics Lab at Virginia Tech! Our goal is to create robots that work alongside people to perform everyday tasks. We develop algorithms for human-

robot interaction: enabling robots to intelligently model and proactively influence their partner's behavior. Our research explores the intersection of machine learning, control theory, and cognitive science, with applications in personalized and assistive robots.

Complex Systems Lab

Director: Nicole Abaid
Our research focuses on the dynamics and control of multi-agent systems with real-world applications. Current projects include modeling and control of animal group behavior, neural networks, and collaborative human-robot teams.

Design, Research & Education of Additive Manufacturing Systems Laboratory

Director: Prof. Christopher Williams
The research mission of the Design, Research & Education of Additive Manufacturing Systems Laboratory (DREAMS) is to be a leader in the transition of rapid prototyping technologies to the new paradigm of additive manufacturing.

Energy Harvesting and Mechatronics Research Laboratory

Director: Prof. Lei Zuo
The Energy Harvesting and Mechatronics Research Laboratory conducts applied and fundamental research in energy harvesting, vibration control, mechatronics design, vehicle dynamics, thermoelectric materials, smart structures, and advanced sensors. Multi-disciplinary approaches are taken to address the challenges on large scale energy harvesting (from ocean wave, wind, etc.), energy harvesting for self-power control (vehicles and civil structures), energy harvesting for autonomous sensors and IoTs, and advanced manufacturing of energy harvesting materials.

Future Materials Laboratory

Director: Prof. Reza Mirzaeifar
In the Future Materials Laboratory, we are developing and utilizing a unique set of multiscale experimental and computational methods to study the mechanical behavior of a broad range of advanced materials, at the atomistic, micro, and macroscales. We fabricate novel metal-graphene composites at different length scales, 3D print alloys, and fabricate nano-sized polymer fibers and sheets. In each case, we perform cutting edge experiments combined with multiscale computational studies to engineer the nano, and microstructure of the materials to obtain exceptional mechanical properties.

Granata Biomechanics Lab

Director: Dr. Robin Queen
Kevin P. Granata Biomechanics Lab (Granata Lab) studies changes in movement mechanics that result from injury and surgical interventions. In addition, we work to design and test new technologies for the assessment of movement and load distribution in non-laboratory systems and we are beginning to collaborate to advance assessment methods in in-home settings.

Heat Transfer Measurements Laboratory

Director: Prof. Thomas Diller
The Heat Transfer Measurements Lab (HTML) performs heat transfer measurements across different length scales: nano, micro, and macro. Facilities include time-domain thermo-

reflectance equipment to measure nano to microscale heat conduction, thermoelectric measurement systems, heat flux calibration systems for convection, conduction, and radiation modes, as well as heat flux sensor fabrication equipment.

Heat Transfer and Safety Laboratory

Director: Prof. Juliana Pacheco Duarte Heat Transfer and Safety Laboratory (HEATS) conducts experimental and computational investigation of two-phase flow phenomena such as post-critical heat flux heat transfer, boiling, and condensation. Our research efforts focus on the thermal-hydraulics and safety analysis of advanced nuclear systems to improve safety, security and economic features of the next generation of nuclear reactors. We work with verification and validation of subchannel and system thermal-hydraulics codes and inverse heat transfer problems.

High Performance Computational Fluid Thermal Science and Engineering Group

Director: Prof. Danesh Tafti The High Performance Computational Fluid Thermal Science and Engineering Group focuses on research in the advancement and application of computational methods and tools to aid the physical understanding of biological, and bioinspired fluid-thermal systems.

Innovative Ship Design Laboratory

Director: Stefano Brizzolara The Innovative Ship Design Laboratory (iShip) at Virginia Tech is a research group, aimed at the development of new designs and design tools for innovative ships and autonomous marine vehicles, with principal support from ONR and DARPA.

Intelligent Transportation Laboratory

Director: Prof. Saied Taheri The mission of the Intelligent Transportation Laboratory (ITL) is to improve the road transportation safety through development and application of the state-of-the-art sensors, actuators, and control systems.

Laboratory for Graphene-X and Thermal Engineering

Director: Prof. Roop L. Mahajan The laboratory houses a facility for synthesis of graphene from coal and graphite. It includes a probe-type ultra-sonicator, a centrifuge machine, three chemical hoods, high-energy ball-milling device and conventional ball-milling and other related characterization and testing equipment. The laboratory is also a home to experimental rigs for measurement of thermal conductance and convective transport in interface materials and high porosity foams.

Laboratory of Transport Phenomena for Advanced Technologies

Director: Prof. Rui Qiao The Laboratory of Transport Phenomena for Advanced Technologies focuses on atomistic, mesoscopic, and continuum simulation of transport phenomena including fluid, ion, thermal, and particulate transport. These researches are driven by challenges emerging at the frontiers of advanced technologies such as dewatering, turbine engine protection, electrical energy storage, and

thermal management.

Li Energy Storage Systems Laboratory

Director: Prof. Zheng Li Li Energy Storage Systems (LESS) lab focuses on the design and development of energy storage materials, systems and their manufacturing process that provide technically and economically viable energy storage solutions for electric transportation and power grids.

Mechanics of Complex Materials Lab

Director: Prof. Maryam Shakiba Mechanics of Complex Materials Lab (MCML). We use theoretical and computational mechanics to unravel the link between the composition, microstructure, and performance of complex and advanced materials under different extreme environmental and mechanical loadings. This integration of computational techniques and material sciences provides engineers and researchers a tool to design sustainable, multifunctional, and additively manufactured systems.

Mechanics of Living Material Lab

Director: Prof. Sohan Kale The Mechanics of Living Materials Lab studies emergent behaviors in cells and tissues with a multiscale materials approach. We develop theoretical and computational models for active, dynamic, and coupled mechano-bio-chemical behaviors on subcellular, cellular, and tissue scales relevant in physiology, health, and diseases.

Micro/NanoScale Biotic/Abiotic Systems Engineering Laboratory

Director: Prof. Bahareh Behkam Micro/NanoScale Biotic/Abiotic Systems Engineering (MicroN BASE) laboratory's interest is in experimental and theoretical investigation of phenomena at the interface of biological and synthetic systems at the micro and nanoscale. Current research activities are: (1) Developing bio-hybrid micro-robotic systems in which biological components are utilized for actuation, sensing, communication, and control (e.g. bacteria-enabled autonomous drug delivery systems for cancer therapy) (2) Studying mechanism of adhesion, motility and sensing in mammalian cells and unicellular microorganisms (e.g. effect of surface nano-topography on fungal biofilm formation). We utilize 2D and 3D microfluidic platforms to establish well-defined and repeatable test environments for most of our projects.

Multiphase Flow and Thermal-hydraulics Laboratory

Director: Prof. Yang Liu The Multiphase Flow and Thermal-hydraulics Laboratory (MFTL) performs experimental and computational studies on various multiphase flow and reactor thermal-hydraulics topics. In the first area, we study the full spectrum of two-phase flow regimes that are of practical interest, ranging from bubble nucleation to film and droplet dynamics. Research activities include advanced instrumentation development, experimental studies, and model development for both 1-D system codes and 3-D CFD codes. In the area of reactor thermal-hydraulics, the focus is on reactor safety related issues. Specific topics include air entrainment in the emergency core cooling system, flow structure development in rod bundles, flow induced vibration on piping

elements, passive safety systems, and spent fuel pool safety. MFTL has several test loops for two-phase flow experiment and instrumentation development. These test loops are equipped with high-precision instruments including magnetic flow meters, air mass flow meters, and differential pressure transducers. An existing high-speed imaging system consists of multiple (up to five) high-speed cameras, with an attainable frame rate up to 500,000 fps and resolution up to 6016x1024 pixels. A fast X-ray line-detector system can provide X-ray imaging at spatial resolution of 100 micrometer and a frame rate exceeding 1000 Hz. MFTL also has the capability to develop in-house instrumentation systems, such as multi-sensor conductivity probes, impedance void meters, and film thickness sensors. The dedicated computing resources include a 64-core AMD Opteron workstation and several multi-core Intel Xeon based workstations. The lab has access to Virginia Tech's high-performance computing systems, which houses more than five high performance clusters and necessary software packages including ANSYS CFX, ANSYS FLUENT and OpenFOAM, to perform single- and multi-phase CFD simulations.

Nature-Inspired Fluids & Interfaces

Director: Jonathan Boreyko The Nature-Inspired Fluids & Interfaces laboratory (NIFI) studies novel materials and phenomena exhibited by animals, plants, and the environment. We then exploit these to design innovative technology, with a focus on advanced materials, water harvesting, and renewable energy. For example, building synthetic trees that mimic the transpiration cycle of natural plants, to collect fresh water or for energy generation. Our research is a multi-disciplinary combination of fluids dynamics, phase-change heat transfer, materials science, and thermodynamics.

Ng Laboratory

Director: Prof. Wing Ng The Ng Laboratory is a state-of-the-art research facility dedicated to advancing the core technologies and capabilities of aerospace propulsion and ground-based power generation. It is part of the Advanced Power and Propulsion Laboratory which houses four test cells and a fundamental research laboratory with a number of experimental rigs that simulate the flow and thermal conditions throughout propulsion engines and gas turbines.

Nonlinear Systems Laboratory

Director: Prof. Craig Woolsey The Nonlinear Systems Laboratory (NSL) in the Aerospace and Ocean Engineering Department at Virginia Tech provides a facility for research and instruction in dynamics and control of nonlinear systems, with particular focus on autonomous ocean and atmospheric vehicles. Founded in 2005, the NSL is co-directed by Dr. Cornel Sultan, Dr. Mazen Farhood, and Dr. Craig Woolsey. The Lab supports Virginia Tech's Autonomy and Robotics group.

Nuclear Science and Engineering Laboratory

Director: Prof. Alireza Haghighat The Nuclear Science and Engineering Laboratory (NSEL) is a unique research laboratory strategically located

within a regional triangle of the Virginia Tech Research Center (VTRC) at Arlington, the Virginia Tech Campus in Blacksburg, and the Center for Advanced Engineering and Research (CAER), an industry-based research hub in New London, Virginia. Under the auspices of the Institute for Critical Technology and Applied Science (ICTAS), NSEL facilitates collaboration among its members and government agencies, industrial organizations, and educational institutions. It draws the expertise of faculty members from different disciplines and promotes nuclear education by offering workshops, courses, and seminars. NSEL enables the VT Nuclear Engineering Program to fill a void in nuclear education and research in the National Capital Region. It is expected that NSEL activities will lead to establishment of new centers, vigorous research activities, engagement in nuclear policy development, and innovations of new tools and devices and computational tools for application in nuclear power, nuclear security and safeguards, and radiation diagnosis and therapy. NSEL will contribute to enhancing nuclear education in the NCR, and training of the next generation nuclear scientists and engineers. In August 2015, NSEL signed an agreement with the US Naval Academy (USNA). Under this agreement, VT faculty and students engage with the USNA midshipmen and faculty in joint research and educational activities and benefit from the nuclear facilities at USNA.

Occupational Ergonomics and Biomechanics Laboratory

Co-Director: Profs. Mike Madigan, Maury A. Nussbaum, and Divya Srinivasan The Occupational Ergonomics and Biomechanics Laboratory (OEB) conducts work in theoretical and applied ergonomics, occupational biomechanics, and work physiology, primarily relating to worksite, workstation, and equipment evaluation and design. Research in the lab addresses: biomechanics of the human body (modeling, strength, motions, and working postures); human engineering of systems, equipment, tools, workstations, and work tasks; and ergonomic design for safety, efficiency, and performance. Two primary areas of emphasis are the prevention of musculoskeletal disorders and slip/trip/fall accidents.

Performance Engineering Research Laboratory

Director: Prof. Steve Southward The mission of the Performance Engineering Research Laboratory (PERL) is to enhance the performance of sport, military, industrial, and commercial vehicles with the development and application of innovative active & adaptive control strategies. Our goal is to advance the state-of-the-art in vehicle suspension design, testing, and optimization with breakthrough innovations for improving vehicle ride and handling.

Radiation Measurement and Simulation Laboratory

Director: Assoc. Prof. of Practice Mark Pierson The Radiation Measurement, and Simulation and Visualization Laboratory (RMSVL) supports research activities in radiation detection and materials, radiation dosimetry, light-weight radiation shielding materials, radiation

detection arrays, medical physics, nuclear safeguards, design of passive and active interrogation systems, and benchmarking of particle transport codes and radiation transport visualization. In addition, it provides modeling and simulation and visualization of the results. Finally, it provides radiation literacy through experiments conducted by students in the various nuclear engineering courses. Equipment included in the lab: Reverse electrode Germanium detector, 60% efficiency with hybrid cryostat Digital spectrum analyzer NaI and LaBr scintillation detectors Various radiation detection instruments and probes Lead-shielded counting systems 32 processor computational cluster

Robotics and Mechatronics Laboratory

Director: Prof. Pinhas Ben-Tzvi The Robotics and Mechatronics Laboratory's mission is to conduct advanced fundamental and applied research in robotics, intelligent autonomous systems, robotic vision and visual serving/odometry, machine learning, human-robot interactions, mechatronics design, systems dynamics and control, mechanism design and system integration, and novel sensing and actuation. Examples of research application areas and projects include autonomous mobile robots with symbiosis of locomotion and manipulation and modular and reconfigurable mobile robotics for search & rescue and hazardous environment sensing and monitoring; intelligent bio-inspired robotic tails for robust dynamic stabilization and agile maneuvering of legged robots on rough terrain; haptics devices and upper-extremity exoskeletons for tele-operation and rehabilitation; autonomous unmanned aerial vehicle (UAV) launch and recovery from naval vessels; advanced medical devices and robotic systems for precision surgery; and novel smart sensors and actuators for biomedical applications.

Ross Dynamics Laboratory

Director: Prof. Shane Ross The Ross Dynamics Laboratory at Virginia Tech specializes in applications of nonlinear dynamics, performing mathematical modeling, simulation, visualization, and experiments with applications in several different fields, including: patterns of dispersal in oceanic and atmospheric flows, passive and active aerodynamic gliding, dynamic buckling of flexible structures, transport across the air-water interface, orbital mechanics, chemical physics, and causality analysis in complex natural and artificial systems.

Soft Materials and Structures Lab

Director: Prof. Michael D. Bartlett The research in the Soft Materials and Structures Lab lies at the intersection of soft materials, mechanics, and functionality. Through precise experiments and analyses, we study and exploit the fascinating interplay between material composition, geometry, and programmed deformations. This interdisciplinary and biomimetic approach aims to create advanced, multifunctional materials with novel combinations of mechanical and functional properties, including 'smart' adhesives, deformable electronics and soft robotics, and adaptive materials.

Spinneret based Tunable Engineered Parameters Laboratory

Director: Prof. Amrinder Nain The Spinneret based Tunable Engineered Parameters (STEP) is a pseudo dry spinning technique that allows the deposition of nano-micron sized diameter fibers with user defined control of diameter, spacing, and deposition angle.

Terramechanics, Multibody, and Vehicle Systems Laboratory

Director: Prof. Corina Sandu The Terramechanics, Multibody, and Vehicle Systems (TMVS) Laboratory educates students and conducts research in a broad range of fundamental and applied topics in the three main areas mentioned in its name: terramechanics (vehicle-terrain interaction, tire/track modeling, vehicle mobility, soil/terrain modeling), multibody systems (modeling, simulation, uncertainty quantification, parameter estimation, sensitivity analysis, design optimization), and vehicle dynamics (tire dynamics, suspension modeling; handling, ride, and performance analysis).

Terrestrial Robotics and Control Laboratory

Director: Prof. Alex Leonessa The Terrestrial Robotics and Controls Laboratory (TREC) at Virginia Tech is a facility for graduate and undergraduate robotics research and education with an emphasis on studying novel mobile robot locomotion strategies, such as bipedal, quadrupedal, and soft robotics. Potential areas of application are exoskeletons for rehabilitation and performance enhancement, search and rescue, precision agriculture, just to mention a few.

Theoretical and Applied Fluid Mechanics Group

Director: Mark A. Stremler The Theoretical and Applied Fluid Mechanics (TAFM) Group conducts research on a range of topics in fluid mechanics, including reduced-order mathematical, numerical, and experimental models of fluid flows, with an emphasis on fluid-structure interaction, flows dominated by coherent vortical structures, microfluidic systems, fluid dynamics in biological systems, and connections to dynamical systems theory, particularly applications to fluid mixing.

Thermal Radiation Group

Director: Prof. Robert Mahan The Thermal Radiation Group conducts fundamental and applied research in optical and thermal radiation phenomena with applications in the fields of Earth radiation budget monitoring, infrared low observables, calibration, and related instrumentation.

Unmanned Systems Laboratory

Director: Prof. Kevin Kochersberger The Unmanned Systems Laboratory brings together a diverse collection of researchers to a common facility dedicated to autonomous and remotely operated systems development and integration.

VT Railroad Advanced Initiatives Laboratory

Director: Prof. Mehdi Ahmadian The Railway Technology Laboratory (RTL), part of the Center for Vehicle Systems and Safety (CVeSS) at Virginia Tech, was established in 2004 as an Association of American Railroads (AAR) affiliated laboratory. Dr. Mehdi Ahmadian, J. Bernard Jones Chair Professor of Mechanical Engineering, is the founding

director of RTL. RTL explore advanced technologies for the railroads and their suppliers to be more efficient and competitive in their day-to-day operations, conduct state-of-the-art scientific and experimental research in railroad and rail vehicles, and create a productive environment for educating both graduate and undergraduate students to better serve their future employers. Currently, RTL is a member of consortium (called "RailTEAM") of Virginia Tech, UNLV, and the University of Delaware, which is the only DOT University Transportation Center (DOT-UTC) in rail transportation.

Vehicle Terrain Performance Laboratory

Director: Prof. John Ferris
The mission of the Vehicle Terrain Performance Lab (VTPL) is to improve vehicle system performance by studying the interactions between vehicles and terrain.

Veterinary-Medicine Sensor Development Group

Director: Dr. Mary Kasarda (maryk@vt.edu)
Our group explores the development of non-invasive sensing approaches, such as the application of computer-vision and acoustic measurement techniques, for monitoring animals in veterinary-medicine and animal-care scenarios to help support improvements in the health and well-being of animals. For example, our research in computer-vision applications lays the groundwork for robust tool development for noninvasively monitoring horses, and without the required presence of humans, in such applications as post-operative monitoring, foaling, evaluation of performance horses in competition, as well as for providing quantitative data for research on animal behavior and welfare, among other scenarios. Dr. Kasarda is an affiliate faculty in the CENTAUR Center in the Virginia-Maryland College of Veterinary Medicine at Virginia Tech.

Vibrations & Acoustics Laboratory

Director: Prof. Christopher Fuller
The Vibrations and Acoustics Laboratory's (VAL) mission is to devote our research staff and facilities to the solution of major scientific problems in vibrations and acoustics and to improving the quality of life as far as noise pollution, in the communities that we serve. One of our primary goals is to develop seminal new knowledge and solutions to difficult problems in sound and vibration. In addition, we aim to provide a foundation of knowledge, expertise and leadership in the field of sound and vibration control.

Vibrations, Adaptive Structures and Testing Laboratory

Director: Prof. Pablo Tarazaga
Vibrations, Adaptive Structures and Testing Laboratory (VAST) studies the dynamic behavior of structures from very large inflatable satellites (Gossamer Structures) to micron size stereocilia. Adaptive Structures research relates to structures that have the ability to adapt, evolve or change their properties or behaviour in response to the environment around them" (taken from Adaptive Structures: Engineering Applications).

Virginia Tech Microelectromechanical Systems Laboratory

Director: Prof. Masoud Agah
Virginia Tech Microelectromechanical Systems Laboratory (VT MEMS Lab) The current research at VT MEMS

Lab centers on the development of CMOS-compatible three-dimensional silicon micro-machining techniques, smart microchip coolers, micro gas analyzers for environmental and healthcare applications, and bio-chips for cancer diagnosis and cancer treatment monitoring. In addition, the lab is pursuing research to merge MEMS (top-down approach) and nanotechnology (bottom-up approach) in order to enhance the performance of the micro-systems under development in our group.

Virginia Tech Smart Infrastructure Laboratory

Director: Prof. Pablo Tarazaga
The Virginia Tech Smart Infrastructure Laboratory (VTSIL) works to advance research and education in topics that utilize sensor information to improve the design, monitoring and daily operation of civil and mechanical infrastructure as well as to investigate how humans interact with the built environment.

Visionarium

Director: Prof. Nicholas Polys
Visionarium Laboratory for virtual 3-D visualization was upgraded in June 2016, with a new immersive projection system: the HyperCube. Like the CAVE and VisCube before it, the HyperCube has three rear-projected ten foot square walls and a top-projected floor with a cutout hiding a MOOG motion platform. The HyperCube features numerous hardware and software upgrades to increase the performance and fidelity of the visualization, including: more pixels (2560x2560 active stereo per wall), more brightness, more contrast, surround sound, as well as a new optical tracking system. The HyperCube is connected to the ARC clusters using the 10Gbps VT-RNet. Numerous scientific visualization, 3D authoring, conversion, and publishing software are available on PID-accessible Lab workstations.

X-ray Systems Laboratory

Director: Prof. Guohua Cao
The X-ray Systems Laboratory houses two micro-CT systems. One is a carbon-nanotube based dynamic micro-CT scanner (DynaTom). This micro-CT scanner is one of the world's best in 4D micro-CT imaging of small-animal models with high spatial and temporal resolution and minimum radiation dose. Another is a bench-top micro-CT platform (Xplorer) for early proof-of-concept development of novel imaging technologies. Overall, the X-ray Systems Laboratory focuses on the system engineering of next-generation CT systems through novel x-ray sources, detectors, and algorithms. The lab has the following resources: two x-ray shielding rooms of 12' by 9' dimension each and rated for up to 80kVp two optical tables one Pfeiffer HI CUBE vacuum pump station a custom-built CNT field emission measurement station one chemical hood for electro-polishing vacuum parts several workbenches for electrical and mechanical assembling several motorized electromechanical devices including 1 goniometer, 3 linear stages and 2 rotation stages four Dell PC's for CAD design, numerical simulations, data acquisition and equipment control. Machine shop services are readily available on VT campus.

DEGREES OFFERED

MEng Degree

Offered In (Blacksburg, Hampton Roads, National Capital Region)

TOEFL

iBT: (105.0)

GRE

General Test: Analytical Writing (4.5), Verbal (150.0), Quantitative (165.0)

IELTS

English Proficiency: (7.0)

The MEng program seeks to educate graduate engineering students by delivering a broad-based theoretical curriculum developing students' ability to address specific engineering problems in order to enhance industry and the technical community. Please contact megrad@vt.edu for specific location information. Acceptance into the VT Mechanical Engineering graduate program is based on the overall application package. In general, the minimum target requirements are to the left. The application materials required can be accessed from the ME application instructions web page. Master of Engineering (MENG) Degree Requirements The Master of Engineering Degree (MENG) in Mechanical Engineering is primarily intended for individuals working in industry/government, and pursuing this degree on a part-time basis. Students must complete a minimum of 30 semester hours of technical graduate study beyond the baccalaureate, not including supporting courses. Because the MENG requires more technical coursework hours (24) and only project hours (6), departmental funding is not available. MENG students must submit a Plan of Study to the Graduate Coordinator before completing the first semester registered as a MENG student. The Master of Engineering Degree in Mechanical Engineering must include the following minimum requirements: 1. Project and Report (ME 5904): 6 hours minimum 2. Approved technical coursework meeting the following: 24 hours minimum Courses numbered 5000, or higher: 18 hours minimum ME Technical Course Work: 9 hours minimum Courses outside the student's specialization area: 6 hours minimum ME approved Mathematics or Statistics: 3 hours minimum A maximum of two Virginia Tech 4000 level courses are allowed to meet degree requirements and should be on the ME Technical Elective List for undergraduate ME students. If it is a conjoint course, it must be taken at the 5000 level. A maximum of 6 hours of Special Study (5984 only), and a maximum of 6 hours of Independent Study (5974 only), with the total of both not to exceed 9 hours is allowable. Transfer courses meeting Graduate School policies, are listed and approved on the Plan of Study. Graduate School requires a Diversity and Inclusion component for all graduate students. Please see the ME Graduate Studies Guide for further information about this supporting course. Seminar Program: All Blacksburg students must participate in the Mechanical Engineering program seminar series each semester by registering in ME 5944. Ethics: All graduate students must meet the Graduate School's Ethics requirement by completing the supporting course, GRAD 5014 Academic Integrity & Plagiarism, within their first 2 semesters. A written Project & Report is required for the Final Defense. No courses below the 4000 level are accepted to meet graduate degree requirements. Contact the ME graduate program for approval procedures before taking any Independent Study (5974 only) courses.

Degree Concentrations:

Nuclear Engineering Graduate Certificate

A student must take a total of at least 9 credit hours with a letter grade of 'B' or better in every course to obtain the Nuclear Engineering Graduate Certificate. Six credit hours from 5000-level courses or, higher are required. More information is available in the Graduate Catalog. Required: NSEG 5114 Nuclear Engineering Fundamentals: 3 credits Electives: Minimum 6 credit hours from the approved course list (at least 3 credit hours at the 5000-level or higher)

PhD Degree

Offered In (Blacksburg, Hampton Roads, National Capital Region)

TOEFL

iBT: (105.0)

GRE

General Test: Analytical Writing (4.5), Verbal (150.0), Quantitative (165.0)

IELTS

English Proficiency: (7.0)

The PhD program seeks to prepare graduate students to think critically by generating a novel engineering research problem and using their technical competence to craft and conduct experimentation leading to research methodology from concept to completion. Students will present their research as the leading expert in the research field and will contribute publications, innovative research, and other scholarly activities to benefit the global community. Please contact megrad@vt.edu for specific location information. Acceptance into the VT Mechanical Engineering graduate program is based on the overall application package. Admission does not guarantee financial assistance. In general, the minimum target requirements are to the left. The application materials required can be accessed from the ME application instructions web page. Doctor of Philosophy (PhD) Degree Requirements The Doctor of Philosophy (PhD) in Mechanical Engineering requires students to complete a minimum of 90 semester hours of technical graduate study (with stipulations listed below) beyond the baccalaureate, pass a qualifying exam, preliminary exam, and complete a research dissertation. PhD students must submit a Plan of Study before completing the second semester registered as a PhD student. Much of the course work from the Masters degree is allowed towards the PhD. The Plan of Study must meet the following minimum requirements: Research & Dissertation (7994): 30 hours minimum Approved technical ME graduate courses: 15 hours minimum Additional approved technical graduate courses: 15 hours minimum Additional hours of either research (7994) or technical coursework: 30 hours minimum Technical courses numbered 5000, or higher: 27 hours minimum Once course requirements in number 2 above are met, students are allowed a maximum of two Virginia Tech 4000 level courses. These courses must be on the Technical Elective List for undergraduate ME students. If it is a conjoint course, it must be taken at the 5000 level. ME approved Mathematics or Statistics: 3 hours post baccalaureate For continuously enrolled VT students completing an MS, most or all coursework counts towards the PhD. Transfer courses (including from a non-VT MS degree) meeting Graduate School policies, are listed and approved on the Plan of Study. Independent/Special Study Courses (5974 and 5984): 12 hours maximum Graduate School requires a Diversity and Inclusion component for all graduate students. Please see the ME Graduate Studies Guide for further information about this supporting course. Seminar Program: All Blacksburg students must

participate in the Mechanical Engineering program seminar series each semester by registering in ME 5944. Ethics: All graduate students must meet the Graduate School's Ethics requirement by completing the supporting course, GRAD 5014 Academic Integrity & Plagiarism, within their first 2 semesters. No courses below the 4000 level are accepted for graduate credit. Contact the ME graduate program for approval procedures before taking any Independent Study (5974 only) courses. In addition, doctoral students matriculating with an MS degree must pass the PhD Qualifying exam within their first 3 semesters, as well as passing a Preliminary Exam/Proposal Defense at least 6 months prior to the Final Defense. A written Dissertation is required for the Final Defense. Direct PhD MS Students may skip the MS and enroll as a "Direct-PhD" upon passing the PhD Qualifying exam within their first 4 semesters and securing a PhD Research Faculty Mentor. All PhD requirements are the same as listed above.

Degree Concentrations:

Nuclear Engineering Graduate Certificate

A student must take a total of at least 9 credit hours with a letter grade of B or better in every course to obtain the Nuclear Engineering Graduate Certificate. Six credit hours must be from 5000-level courses or higher. More information is available in the Graduate Catalog. Required: NSEG 5114 Nuclear Engineering Fundamentals: 3 credits Electives: Minimum 6 credit hours from the approved course list (at least 3 credit hours must be at the 5000-level or higher)

MS Degree

Offered In (Blacksburg, Hampton Roads, National Capital Region)

TOEFL

iBT: (105.0)

GRE

General: Verbal (150.0), Quantitative (165.0), Analytical (4.5)

IELTS

English Proficiency: (7.0)

The thesis MS program seeks to prepare graduate students by providing them with practical and theoretical engineering knowledge, training the students to be able to become technical leaders, design a research methodology which solves an existing engineering problem, to present on their research, and to contribute to the scholarly work of the global mechanical engineering community. The non-thesis MS program seeks to educate graduate engineering students by providing them with preparation in the essential sciences and technology of Mechanical Engineering. This option complements our current offerings and provides potential graduate students with another opportunity which may better suit their needs, than the MS with thesis option. The non-thesis MS program involves academic course work, a research component related to coursework or, a review of research papers and concludes with a final presentation to the Examination Committee. The purpose is to ensure a research component is preserved through this MS degree program. This degree option may be more applicable for those applicants who are interested in part-time studies, who are employed and pursuing professional development, or careers in industry. Please contact meggrad@vt.edu for specific location information. Acceptance into the VT Mechanical Engineering graduate program is based on the overall application package. Admission does not guarantee financial assistance. In general, the minimum target requirements are to the left.

The application materials required can be accessed from the ME application instructions web page. Master of Science (MS) Thesis Degree Requirements The Master of Science (MS) in Mechanical Engineering requires students to complete a minimum of 30 semester hours of technical graduate course study beyond the baccalaureate, and complete a research thesis. MS students must submit a Plan of Study before completing the first semester registered as a MS student. The MS in Mechanical Engineering must include the following minimum requirements: Research and Thesis (5994): 6 hours minimum (A maximum of 10 hours of 5994 is allowed. Students should register in additional research hours as ME 7994 towards the PhD and these hours should not appear on the MS plan of study.) Approved technical coursework meeting the following requirements: 20 hours minimum Courses numbered 5000, or higher: 15 hours minimum ME Coursework: 9 hours minimum ME approved Mathematics or Statistics: 3 hours post baccalaureate A maximum of two Virginia Tech 4000 level courses is allowed to meet degree requirements and must be on the ME Technical Elective List for undergraduate ME students. If it is a conjoint course, it must be taken at the 5000 level. A maximum of 6 hours of Special Study (5984 only), and a maximum of 6 hours of Independent Study (5974 only), with the total of both not to exceed 9 hours is allowed. Transfer courses meeting Graduate School policies, are listed and approved on the Plan of Study. Master of Science (nt-MS) Non-thesis Degree Requirements Departmental funding is not available for the non-thesis Master of Science (nt-MS) program as this program does not require research hours but does require more coursework (24). The nt-MS (non-thesis) in Mechanical Engineering must include the following minimum requirements: Project and Report (5904): 1-6 hours Approved technical coursework meeting the following requirements: 30 hours minimum Courses numbered 5000, or higher: 18 hours minimum ME Coursework: 9 hours minimum ME approved Mathematics or Statistics: 3 hours post baccalaureate A maximum of two Virginia Tech 4000 level courses are allowed to meet degree requirements and must be on the ME Technical Elective List for undergraduate ME students. If it is a conjoint course, it must be taken at the 5000 level. A maximum of 6 hours of Special Study (5984 only), and a maximum of 6 hours of Independent Study (5974 only), with the total of both not to exceed 9 hours is allowed. Transfer courses meeting Graduate School policies, are listed and approved on the Plan of Study. Graduate School requires a Diversity and Inclusion component for all graduate students. Please see the ME Graduate Studies Guide for further information about this supporting course. Seminar Program: All Blacksburg students must participate in the Mechanical Engineering program seminar series each semester by registering in ME 5944. Ethics: All graduate students must meet the Graduate School's Ethics requirement by completing the supporting course, GRAD 5014 Academic Integrity & Plagiarism, within their first 2 semesters. No courses below the 4000 level are accepted for graduate credit. Contact the ME graduate program for approval procedures before taking any Independent Study (5974 only) courses.

Degree Concentrations:

Nuclear Engineering Graduate Certificate

A student must take a total of at least 9 credit hours with a letter grade of B or better in every course to obtain the Nuclear Engineering Graduate Certificate. Six credit hours must be from 5000-level courses or higher. More information is available in the Graduate Catalog. Required: NSEG 5114 Nuclear Engineering Fundamentals: 3 credits Electives: Minimum 6 credit hours from the approved course list (at least 3 credit hours must be at the 5000-level or higher)

GRADUATE COURSES (ME)

ME 5034:

Bio-Inspired Technology

Introduction to engineering solutions inspired by the functional mechanisms of biological systems. An overview of bio-inspired technology and the state of the art. Exploration of the relationship between engineered and natural biological systems. Concepts of biological systems, such as evolutionary optimization, sensing, actuation, control, system integration, assembly, and materials in engineering terms. State-of-the art of bio-inspired technology. Interdisciplinary analysis skills are practiced in projects where man-made and biological systems are evaluated for parallels and the technological potential of the biological systems. Prerequisite: Graduate Standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ME 5104:

Thermodynamics: Foundations and Applications

Exposition of the basic concepts and principles of thermodynamics. Principles and results developed for both macroscopic and microscopic systems as well as equilibrium and non-equilibrium states. Definition of entropy for any state. The definition of temperature; pressure, total potential; heat; work; the fundamental Gibbs, Euler, Gibbs-Duhem, and Maxwell relations; characteristic functions; and the state principle. Definition and use of thermo-physical properties, charts, tables, and equations of state for pure as well as mixtures of ideal and real gases, liquids and solids. Second Law analysis, energy conversion, chemical reactions and chemical equilibrium, and introduction to the phenomenological laws of non-equilibrium thermodynamics. I.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ME 5135 (AOE 5135):

Vehicle Propulsion

Aerothermodynamics of gas turbines and rockets: cycle analysis of

turbojets, turbofans, prop fans, and turbo props. Analysis of ramjets and scramjets. Performance of inlets, combustors, and nozzles. Elementary theory of turbomachinery. Liquid and solid propellant chemical rockets. Electrostatic, electromagnetic, and electrothermal propulsion. Integrated rocket-ramjet. Fuels and propulsion systems for future transportation system.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

ME 5174 (BMES 5174):

Biomechanics of Crash Injury Prevention

Principles of design and analysis of crash injury prevention methods in vehicle crashes. The course encompasses three major focus areas for occupant protection in crashes: crash energy absorption in (1) the vehicle structure, (2) the occupant, and (3) the occupant restraints. Topics include the biomechanics of impact injury, analysis of occupant response in crash tests, vehicle crash kinematics, modeling of vehicle impact response, modeling of human impact response, and occupant restraint design. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ME 5204 (BMES 5204):

Lab Techniques Injury Prev

Human surrogate biomechanical impact testing. 3-D rigid-body kinematics, kinetics, properties of deformable materials, servosled testing. Injury prediction and mitigation for transport systems. Transportation restraint system design. Instrumentation, data acquisition, and signal processing techniques of impact biomechanics. Pre: Graduate standing.

Credit Hour(s): 4

Lecture Hour(s): 4

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ME 5214:

Combustion

Combustion science and its applications and introduction.

Thermodynamics of gaseous mixtures, chemical kinetics of gases, transport properties of gaseous mixtures, chemical reactors and chemically reacting flows. Waves in chemically reacting flows, deflagrations and deformations. Laminar premixed flames, laminar diffusion flames. Liquid fuels combustion. Pollutants formation in combustion.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

ME 5254:

Fuel Cell Systems

Fuel cell systems for transportation, buildings, utility and portable power energy conversion applications. Overview of fuel cell technology. Thermodynamics of direct energy conversion and fuel cell efficiency. Electrochemistry, equilibrium and reaction kinetics. Temperature and pressure effects on polarization curves. Proton exchange membrane fuel cell performance modeling. Fuel cell system components: heat exchangers, humidifiers, air compressors, electric power processing and management. Overall system integration, modeling, and control. Fuel cells for transportation, vehicle performance and efficiency characteristics. Fuel processing and reformers. Fuel cell system design, economics, and optimization. Graduate standing in Engineering required. II.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ME 5304:

Conduction and Radiation Heat Transfer

Principles of conduction. Analysis of one-dimensional and multidimensional steady and transient, phase change and moving heat source problems are examined. A comprehensive treatment of numerical and analytical methods for solving heat conduction problems is presented.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

ME 5314:

Convective Heat and Mass Transfer

Principles of convection. Analysis of heat transfer for internal and external flows; laminar and turbulent boundary layer theories; forced and natural convection. Analysis using similarity transformations, integral solutions and numerical methods.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ME 5324:

Radiation Heat Transfer

Introduction to thermal radiation; the electromagnetic spectrum; the blackbody; wave phenomena versus geometric optics; polarization, diffraction, and refraction effects; emission, reflection, absorption, and transmission of thermal radiation by surfaces; radiant interchange among surfaces; radiation through a participating medium; the Monte Carlo raytrace method; uncertainty and confidence interval of results. Knowledge of thermodynamics at the undergraduate level is recommended.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ME 5334:

Energy Systems: Theory and Applications

Theory and applications of thermodynamic and fluid mechanics principles as applied to energy systems. Fundamental concepts on exergy, mixtures, psychrometry and thermochemistry. Analyses and applications include vapor and gas power systems, refrigeration, air conditioning, combustion processes and one-dimensional compressible flow. Pre: Graduate Standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ME 5344G:**Advanced Biological Transport Phenomena**

Engineering analysis and predictive modeling of heat and mass transport in biological systems (e.g., tissues, organs, organisms, and biomedical devices). Examination of processes that involve conduction, convection, diffusion, generation/ consumption. Application of analytical and computational methods to solve differential equations that describe unsteady and/or multi-dimensional transport. Topics include oxygen transport, drug delivery, pharmacokinetic analysis, kidney function, blood perfusion, cryopreservation, and hyperthermia. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ME 5404:**Fluid Dynamics**

Fundamental fluid mechanics: kinematics and dynamics. Continuum fluid dynamics including hydrostatics, flow kinematics, the concept of stress, constitutive relations, the equations of motion and energy for compressible and incompressible viscous and inviscid flows. Incompressible Newtonian viscous flows, similitude and physical modeling, inviscid potential flows, inviscid flows with vorticity, boundary layers, and an introduction to turbulent flow. I.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ME 3404

Corequisite(s):

ME 5424:**Turbomachinery**

Application of fluid mechanics and thermodynamics to turbomachinery, with emphasis on high speed machines. Review of basic concepts and ideal performance. Viscous effects - losses and stall. Three dimensional and secondary flow. Actual machine performance and design considerations. Selected topics including axial and centrifugal machines, transonic flow, transient behavior, and three-dimensional flow design. II

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

ME 5434:**Advanced Introduction to Computational Fluid Dynamics**

Euler and Navier-Stokes equations governing the flow of gases and liquids. Mathematical character of partial differential equations. Discretization approaches with a focus on the finite difference method. Explicit and implicit solution techniques and their numerical stability. Introduction to verification, validation, and uncertainty quantification for computational fluid dynamics predictions. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ME 5444:**Interfacial Fluid Mechanics**

Interfacial fluid systems involving surface tension, interfacial hydrodynamics, and phase-change heat transfer. Scaling analysis and non-dimensionalization will be used to model a variety of interfacial phenomena relevant to fluid mechanics and phase-change heat transfer. Capillarity, surface wettability, hydrodynamics of interfaces, flow instabilities, long range forces, convective and diffusive boundary layers, homogeneous and heterogeneous nucleation, and multiphase flows. Pre: Graduating standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ME 5514:**Vibrations of Mechanical Systems**

Single degree-of-freedom systems, multiple-degree-of-freedom system and distributed parameter systems ending in dynamic finite element modeling. Numerical solutions, isolation, absorption, optimal design for vibration reduction, analytical modal methods, transfer function methods. Damping models and analysis.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ME 3504

Corequisite(s):

ME 5524:**Bayesian Robotics**

Principles of autonomous robotics control for unstructured environments.

Probability theory, numerical techniques for recursive Bayesian estimation and multi-sensor data fusion, simultaneous localization and mapping, quantification of belief, Bayesian control. Prerequisite:

Graduate Standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ME 5544 (AOE 5744) (ECE 5744):**Linear Systems Theory**

Advanced introduction to the theory of time-varying and time-invariant linear systems represented by state equations; solutions of linear systems, uniform stability and other stability criteria, uniform observability and controllability, state feedback and observers.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECE 4405 (UG) OR ECE 4405 OR ECE 4624 (UG) OR ECE 4624 OR ECE 4634 (UG) OR ECE 4634 OR ME 4504 (UG) OR ME 4504 OR AOE 4004 (UG) OR AOE 4004

Corequisite(s):

ME 5554 (ECE 5754) (AOE 5754):**Applied Linear Systems**

Develop an applied understanding of state-space representations for linear time invariant multi-input multi-output dynamic systems in both time domain and frequency domain. Introduction to modern state-space control methods; state feedback and output feedback. Realistic design problems with numerical simulations of practical implementations.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECE 4405 OR ECE 4624 OR ECE 4634 OR ME 4504 OR AOE 4004 OR ECE 4405 (UG) OR ECE 4624 (UG) OR ECE 4634 (UG) OR ME 4504 (UG) OR AOE 4004 (UG)

Corequisite(s):

ME 5564 (AOE 5764) (ECE 5764):**Applied Linear Control**

Analysis and design of sampled-data systems, extraction of discrete-time dynamic models from experimental data, and implementation of dynamic compensators on digital processors. In-depth design experience with LQR optimal control and an introduction to Kalman filtering. Realistic design problems with numerical simulations of practical implementations.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ME 5554 OR ME 5544 OR AOE 5744 OR AOE 5754 OR ECE 5744 OR ECE 5754

Corequisite(s):

ME 5574 (ECE 5774) (AOE 5774):**Nonlinear Systems Theory**

Introduction to the theory of systems of coupled, nonlinear, time-varying ordinary differential equations: existence and uniqueness of solutions; continuous dependence on parameters; stability of equilibria and stability analysis techniques; input-to-state stability; input-output stability; nonlinear design techniques including input-state and input-output feedback linearization, backstepping, and sliding mode control.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECE 4405 (UG) OR ECE 4405 OR ECE 4624 (UG) OR ECE 4624 OR ECE 4634 (UG) OR ECE 4634 OR ME 4504 (UG) OR ME 4504 OR AOE 4004 (UG) OR AOE 4004

Corequisite(s):

ME 5584 (AOE 5734) (ECE 5734):**Convex Optimization**

Recognizing and solving convex optimization problems. Convex sets, functions and optimization problems. Least-squares, linear, and quadratic optimization. Geometric and semidefinite programming. Vector optimization. Duality theory. Convex relaxations. Approximation, fitting, and statistical estimation. Geometric problems. Control and trajectory planning. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

Finite Elements in Machine Design

Advanced analysis and design of machine components with emphasis on the finite element method of analysis using commercial software. Structural and continuum elements will be used for both the static and dynamic analysis and design of machine components. Practice oriented analysis techniques and design procedures employable through the finite element method will be developed. Design problems will constitute a significant part of the course. II.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ME 3614

Corequisite(s):

ME 5644:

Rapid Prototyping

Participants will study topics fundamental to rapid prototyping and automated fabrication, including the generation of suitable CAD models, current rapid prototyping fabrication technologies, their underlying material science, the use of secondary processing, and the impact of these technologies on society. The rapid prototyping process will be illustrated by the actual design and fabrication of a part. Partially duplicates ME 4644; credit may only be received for one course. Co: ME 4634 or equivalent background; programming skills.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ME 5654:

Modeling and Simulation of Multibody Dynamic Systems

Develops basic mathematical tools for kinematics and dynamics modeling of planar and spatial rigid multibody dynamic systems. Introduces absolute and relative kinematic constraints and driving constraints. Introduces the virtual work and the generalized force concepts. Derives the equations of motion for constrained rigid multibody systems. Studies the inverse dynamics of kinematically driven systems, equilibrium conditions, and constant reaction forces. Introduces Euler parameters for the orientation of rigid bodies in space. Presents numerical considerations in solving spatial differential-algebraic equations of motion. Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ME 5664:

Global Collaborative Product Development

Participants will study topics fundamental to global collaborative product development, project data management, and collaborative product data management. These topics will be applied during a team project with team members located overseas, utilizing state-of-the-art collaborative engineering and product data management software and hardware technologies. Partially duplicates 4664; credit may only be received for one course. Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): (ME 2024 (UG) OR ME 2024), (ME 4634 (UG) OR ME 4634)

Corequisite(s):

ME 5674:

Tire Mechanics

Introduction to tire mechanics with emphasis on tire modeling for vehicle dynamic simulation. Tire mechanics explained from several view points: engineering mechanics, system dynamics, and empirical procedures. Vehicle dynamic modeling including suspension and steering systems covered providing details on the effect of tire dynamics on vehicle behavior. Real tire data provided to be used for vehicle dynamics simulation.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ME 5684:

Unified System Dynamics

Bond Graph method as a unified tool for modeling and simulation of complex dynamic systems. Coupled subsystems with mixed energy domains and dynamic coupling between subsystems governed by ordinary and partial differential equations. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

425 Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ME 5694:

Advanced Design Project

Teams solve complex engineering problems, typically originating for industry, with emphasis on new product development, using the engineering design process. Emphasis on project management, engineering economics, and professional skills in presentation of a proposed business plan and technical solution. Intended for students in the Virginia Tech - Technische Universitat Darmstadt dual Master of Science in Mechanical Engineering degree program. May be repeated for a maximum of 6 credits, but then in different fields of mechanical engineering. Variable credit of 1-6 hours

Credit Hour(s): 1 TO 6

Lecture Hour(s): 1 TO 6

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ISE 5174

Corequisite(s):

ME 5704 (ECE 5704):

Robotics and Automation

Automation, mechatronics, robot technology, kinematics, dynamics, trajectory planning, and control of two-dimensional and spatial robots; robot programming; design and simulation of robotic devices. Laboratories associated with robot forward/inverse kinematics, task planning, velocity kinematics, force rendering, control, haptics, mobile robotics, mapping/localization, computer vision and path planning. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 2

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

ME 5714 (BMES 5514):

Digital Signal Processing for Mechanical Measurements

The fundamentals of digital signal processing of data experimentally obtained from mechanical systems will be covered. Attention will be given to the data acquisition, A/D conversion, aliasing, anti-aliasing filtering, sampling rates, valid frequency ranges, windowing functions, leakage, and various transform methods. Special attention will be given to random, transient, and harmonic function data processing. Various methods of estimation of the frequency response function (FRF) will be explored. The estimation methods will be assessed as to their impact on

FRF estimation errors. I.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ME 3504, ME 4504

Corequisite(s):

ME 5724:

Advanced Instrumentation and Signal Processing

Advanced techniques in instrumentation using state-of-the-art transducers, techniques in data acquisition and signal processing. Techniques for estimating errors and optimizing data quality.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ME 4005

Corequisite(s):

ME 5734:

Advanced Engineering Acoustics

The fundamental principles underlying the generation, transmission, and reception of acoustic waves will be presented. Methods for analytically investigating various acoustic and structural acoustic situations encountered in practice will be developed. The application of these methods to typical engineering acoustical problems with physical interpretation of the results will be demonstrated.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ME 4724

Corequisite(s):

ME 5735G:

Advanced Mechatronics

Electromechanical design and control applications. Design and building of electronic interfaces and controllers for mechanical devices, sensors, signal acquisition, filtering, and conditioning. Microcontroller-based closed-loop control and device communications. Sensor and actuator selection, installation, and application strategies.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ME 5736G:

Advanced Mechatronics

Electromechanical design and control applications. Design and building of electronic interfaces and controllers for mechanical devices, sensors, signal acquisition, filtering, and conditioning. Microcontroller-based closed-loop control and device communications. Sensor and actuator selection, installation, and application strategies.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ME 5735G

Corequisite(s):

ME 5744:

Methods of Mechanical Engineering Analysis

Introduction to selected mathematical techniques oriented toward solving advanced continuous and lumped parameter problems of the type often encountered in mechanical engineering. Elliptic, parabolic and hyperbolic ordinary and partial differential equations are discussed.

Solution by separation of variables, integral transforms, Greens functions and numerical methods. The emphasis is on understanding how physical processes work.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ME 5764 (BMES 5764):

Modeling MEMS and NEMS

Modeling MEMS and NEMS is about the construction, analysis, and interpretation of mathematical and computational models of microelectromechanical and nanoelectromechanical systems (MEMS and NEMS). A goal throughout the course will be to develop a physical intuition for the fundamental phenomena at these small scales. The material covered will be broad and multidisciplinary including: dimensional analysis and scaling; a review of continuum mechanics; fluid dynamics, elasticity, thermal transport, and electromagnetism at the micro and nanoscales; the modeling of a variety of new MEMS/NEMS devices; and approaches beyond the continuum theory including stochastic and deterministic methods. Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ME 5774:

Introduction to Stochastics

Provide a strong foundation for analyzing stochastic processes and exposure to state-of-the-art techniques. Strengthen existing knowledge of probability and statistics including covariance functions and properties, stationarity and ergodicity, and special density. Introduce stochastic processes and modeling and analysis techniques including Markov Chains, and ARIMA models. Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ME 5794:

Optimization Techniques in Engineering

Fundamental mathematical concepts for optimization and optimality conditions. Classification of optimization techniques/problems in engineering. Concepts of forward and inverse design. Linear programming, 1st and 2nd order gradient-based algorithms. Evolutionary strategies for optimization. Sensitivity analysis. Reliability-based and robustness-based optimization. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ME 5804:

Active Material Systems and Smart Structures - I

Behavior and physics associated with ceramic and polymeric active materials; constitutive models of piezoelectric and electrostrictive ceramics and polymers derived from thermodynamic relationships; development of static and dynamic models of systems that incorporate active materials derived using variational mechanics. Piezoelectric and electrostrictive ceramics and polymers, ionomeric polymers, conductive polymers, and carbon nanotubes will be studied. Applied topics in structural health monitoring, motion control, vibration control, and sensing will be studied.

427 Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ME 3514, ME 3504 OR ME 4504

Corequisite(s):

ME 5814:

Energy Harvesting

Criterion of harvesting, identification of energy sources, theory of vibrations, PSD, measurement and analysis. Selection of materials for energy conversion, piezoelectric, electromagnetic, electrostrictive, magnetostrictive, magnetoelectric, dielectric elastomers, conducting polymers, metal-ceramic composites, electrets, electrostatic, thermoelectric, photovoltaic. Design and characterization, modeling and fabrication of vibration, wind, thermal gradient, and light energy harvesters; resonance phenomenon, equivalent circuits and storage.

Case studies for applications of industrial systems, surveillance, automobiles and the human body. Prerequisite: Graduate Standing

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ME 5854G:

Advanced Nano and Micromechanics of Materials

Analysis of microstructural mechanics, crystal structures, defects, and dislocations. Mechanical behavior of crystalline materials at the microscale. Computational modeling of mechanical behavior in discrete atomistic and molecular systems, including molecular dynamics.

Application of these methods to polymers and other soft materials, biological materials, carbon-based materials, and metallic alloys. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ME 5864G:

Advanced Micro/Nano-Robotics

Overview of micro/nano-robotic systems, physics of reduced length scales (scaling effects in the physical parameters, surface forces, contact mechanics, and micro/nano-scale dynamical phenomena), basics of micro/nano manufacturing, microfabrication and soft

lithography, biomimetic design strategies for mobile micro-robots, principle of transduction, material properties and characteristics of micro/nano-actuators (piezoelectric, shape memory alloy, and a variety of MEMS and polymer actuators), control requirements and challenges of micro/nano-actuators, micro/nano sensors for mobile microrobotic applications, micro/nano-manipulation (scanning probe microscopy, operation principles, designing experiments for nanoscale mechanical characterization of desired samples). Pre-requisite: Graduate Standing required

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ME 5874:

Experimental Robotics

Robot Operating System (ROS) installation and operation, Linux, MATLAB and TCP communication with ROS, Integration of sensor, actuator, microcontroller and onboard computer, Object recognition, Simultaneous localization and mapping, Bayesian control. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ME 5904:

Project and Report

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research, Online Research

Instruction Type(s): Research, Online Research

Prerequisite(s):

Corequisite(s):

ME 5914:

Autonomous Systems Seminar

Weekly technical presentations from local and visiting scholars on current topics related to the theory, design and development, and application of autonomous vehicle systems. Pre-requisite: Graduate standing required

Lecture Hour(s): 1

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ME 5944:

ME Graduate Seminar

This course will consist of a series of 50-minute lectures given by invited guests from industry, government organizations, and other universities as well as ME Ph.D students. May be repeated for a maximum of 6 credits. Graduate standing required.

Credit Hour(s): 1

Lecture Hour(s): 1

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ME 5974:

Independent Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Independent Study, VI

Instruction Type(s): Independent Study, VI

Prerequisite(s):

Corequisite(s):

ME 5984:

Special Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ME 5994:

Research and Thesis

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research, Online Research

Instruction Type(s): Research, Online Research

Prerequisite(s):

Corequisite(s):

ME 6104:

Advanced Topics in Thermodynamics

Exposition of the basic concepts and principles of statistical thermodynamics including statistical mechanics, probability theory, quantum mechanics, kinetic theory, and thermo-physical and transport properties. Presentation of the basic concepts and principles of gas dynamics for compressible flow within normal temperature ranges (i.e. excluding the very high temperatures at which plasmas form). A more in depth look at chemical thermodynamics including chemical equilibrium and chemical kinetics. II.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ME 5104

Corequisite(s):

ME 6434 (AOE 6434):

Computational Fluid Dynamics and Heat Transfer

Overview of numerical methods used in the study of computational fluid dynamics (CFD) and heat transfer. Spatio-temporal finite-difference, finite-volume discretizations, solution of linear systems with direct and iterative methods, algorithms for solving the Navier Stokes and energy equations, and turbulence modeling. Applications to inviscid subsonic, transonic, and supersonic flows and viscous boundary layer. Theory reinforced with hands on programming assignments and the application of commercial CFD packages to select problems.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ME 5404, ME 5314, ME 5104

Corequisite(s):

ME 6444 (CS 6444) (AOE 6444):

Verification and Validation in Scientific Computing

Applicable to scientific and engineering models described by partial differential or integral equations. Software engineering, code verification, and the method of manufactured solutions for generating exact solutions. Estimation of numerical approximation errors in scientific computing. Design and execution of experiments for model validation and model accuracy assessment. Propagation of aleatory and epistemic uncertainty through models. Estimation of total prediction uncertainty in scientific computing simulations. Graduate Standing required

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ME 6544 (AOE 6744) (ECE 6744):

Linear Control Theory

Advanced introduction to the theory of optimal control of time-varying and time-invariant linear systems; Solutions to the linear-quadratic regulator, optimal filtering, and linear-quadratic-gaussian problems; Robustness analysis and techniques to enhance robustness of controllers.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECE 5744 OR ECE 5754 OR ME 5544 OR ME 5554

OR AOE 5744 OR AOE 5754

Corequisite(s):

ME 6574 (ISE 6574) (ECE 6774) (AOE 6774):

Adaptive Control Systems

Introduction to the theory and methodology used to design adaptive controllers for uncertain systems, addressing issue such as input constraints, disturbance rejection, partial measurements, and robustness.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): (ECE 5774, ECE 5744) OR (ME 5544, ME 5574) OR (AOE 5774, AOE 5744)

Corequisite(s):

ME 6744:

Chaos & Nonlinear Dynamics

Overview of theoretical and numerical approaches for the study of nonlinear and chaotic dynamics in science and engineering. Fractals, bifurcation analysis, predictability, strange attractors, and routes to chaos. Roles of dissipation and noise in deterministic chaos. Use of Lyapunov spectra, fractal dimension, information, entropy, correlation functions, and attractor reconstruction to describe chaos. Chaos in iterated maps and systems of nonlinear ordinary differential equations. Spatiotemporal chaos in coupled map-lattices and in systems of nonlinear partial differential equations. Numerical integration of systems of stiff equations, operator splitting, exponential time integration, spectral

and pseudo-spectral methods.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ME 5404, ME 5744

Corequisite(s):

ME 6984:

Special Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ME 7994:

Research and Dissertation

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research, Online Research

Instruction Type(s): Research, Online Research

Prerequisite(s):

Corequisite(s):

MINING ENGINEERING

Kramer Luxbacher, Head

Professors: Kramer Luxbacher; Erik Westman; Roe Yoon;

Associate Professors: Cheng Chen; Mario Karfakis; Christopher Noble; Nino Ripepi; Emily Sarver;

Assistant Professors: Bahareh Nojabaei; Wencai Zhang;

Charles T. Holland Professor: Kramer Luxbacher;

University Distinguished Professor and Nicholas T. Camicia Professor: Roe Yoon;

Graduate Contact: mcrotto@vt.edu

Graduate Contact: chen08@vt.edu

Department Website: <http://www.mining.vt.edu/>

Graduate Site: http://www.mining.vt.edu/Graduate/grad_home.html

The Department of Mining and Minerals Engineering (MinE) offers

advanced graduate degrees (MEng, MS and PhD) that are designed to educate students for high-level challenges in industry, academia, and government. Graduate work may be pursued in several areas of specialization including rock mechanics, ground control, systems analysis, health and safety, mineral and coal processing, applied surface and colloid chemistry, conservation and the environment, mining ventilation, computer modeling/simulation, automation and control, and reservoir/natural gas/shale gas engineering. One or more of the topics may be emphasized within the department at a given time based on the ongoing research activity of the full-time faculty assigned to the department. Graduate students accepted to the program are generally provided financial support through sponsored grants, teaching assistantships or graduate fellowships. A major goal of the department is to afford all graduate students with the opportunity to participate in creative and challenging research projects, which typically lead to scholarly publications in international journals and conference proceedings. The graduate program also recognizes the specific needs of industry professionals with a program that strives to upgrade technological skills of practicing engineers, encourage the pursuit of doctoral-level work, and provide an opportunity for advanced education and career reorientation. The MinE graduate program is administered by the Department Head and a Departmental Graduate Committee. The Departmental Graduate Committee is responsible for identifying high-quality students acceptable for admission, for overseeing the graduate program curriculum, and for establishing and monitoring program standards. The Department Head appoints faculty members to serve on the Departmental Graduate Committee and approves all petition to the Graduate School based upon the recommendations of the committee.

SPECIAL FACILITIES

The Department of Mining and Minerals Engineering at Virginia Tech offers graduate students access to state-of-the-art equipment and world-class facilities for research studies. The facilities include laboratories for advanced computing, mine automation and control, carbon storage, environmental monitoring, geomechanics, health and safety, mineral processing, mine rescue, rock mechanics, subsurface atmospheres, surface and colloids, mine surveying and mine ventilation. The laboratories are supported by a well-equipped mechanical shop.

Department Facilities

The following is a listing of laboratories currently operated and maintained by the department. **Advanced Computing Laboratory:** In addition to the university's state-of-the-art supercomputer systems, the department operates a dedicated computing facility equipped with modern workstations and large-scale printers/plotters. Additionally, the department houses a dedicated supercomputer utilized for CFD and advanced reservoir modeling. **Mine Automation and Process Control Laboratory:** The facilities in the Mine Automation and Process Control Laboratory include 10 workstations equipped with state-of-the-art industrial programmable logical controllers (PLCs) and associated input/output and communication modules. The workstations provide hands-on experience in hardware configuration, software development, input/output wiring, ladder logic programming, analog-digital conversion, loop control and tuning, communication architectures, human interfaces and troubleshooting. **Carbon Storage/Management Laboratory:** This laboratory is home to specialized equipment and instrumentation used in

cutting-edge research programs related to the production of coalbed methane and natural/shale gas and the geologic sequestration of carbon. The facility includes equipment and instrumentation for capacity assessment and field validation of geologic reservoirs and formations.

Environmental Laboratories: The environmental laboratory facilities include instrumentation for routine water/soil analysis and dust monitoring. A new thermogravimetric analyzer and microbalance have recently been installed to allow analysis of organic compounds in dusts and other solid samples. The laboratory is also equipped with a diesel engine and particle size analyzers for investigation of diesel particulate matter. Detailed characterization of both solid and water samples is conducted through cooperation with other laboratories on campus.

Geomechanics Instrumentation Laboratory: The facilities in the Earth Systems Instrumentation Laboratory include a 16-source, 18-receiver ultrasonic tomography system. This system includes a Panametrics ultrasonic pulser, a 16-channel switchbox, PAC Micro-80 piezoelectric transducers, and National Instruments PXI-6115 high-speed digitizers (20 Msamples/sec). Additional equipment includes a 16-channel acoustic emission monitoring system which is used for laboratory passive tomography.

Mineral Processing Laboratories: The facilities in mineral processing include a wide array of laboratory equipment for crushing, grinding, separation, dewatering and drying. In addition, the department operates a modern pilot-plant facility that is home to process units such as ball mills, flotation banks, flotation columns, conditioners, electrostatic/magnetic separators, vacuum filters, ore bins, conveyors, sumps and pumps. Supporting equipment includes a vast array of advanced instruments for particle size analysis, mineralogical characterization and elemental determinations.

Mine Rescue Laboratory: The Mine Rescue Laboratory houses eight Biomarine mine rescue apparatus and associated support equipment, including standard communication, rescue and first aid equipment, as well as personal protective equipment.

Rock Mechanics and Ground Control Laboratory: The rock mechanics facilities include a laboratory for preparation of rock specimens for strength testing, three megapound testing machines (three MTS servo-controlled, stiff-test units with computerized data acquisition facilities, one of which is for dynamic testing at 2 m/sec loading rate), triaxial and two shear testing units, a creep testing machine with digital data acquisition system, equipment for seismic testing of rock in both field and laboratory, and subsidence monitoring equipment.

Shale/Natural Gas Laboratory: The shale/natural gas laboratory is home to a variety of instrumentation and equipment used in the study of shale/natural gas resources. This laboratory is used by faculty engaged in the study of gas transport processes through nanometer-scale pore geometries. Ongoing studies include rock characterization, image processing, and pore-scale simulation.

Subsurface Atmospheres Laboratory: The Subsurface Atmospheres Laboratory houses 3 gas chromatographs and 1 gas chromatograph with

mass spectrometer. The laboratory is utilized for characterization of subsurface atmospheres and systems including underground mine ventilation systems, as well as shale and coal reservoirs. Detectors include flame ionization, thermal conductivity, and electron capture. The facility also has autosampling capability and utilizes associated technologies including two digital mass flow controllers, sample vacuum system, and solid phase microextraction. Surface and Colloid Chemistry Laboratories: Some of the noteworthy facilities of the surface and colloid chemistry laboratories include a UV spectrophotometer, AA spectrometer, FTIR spectrophotometer, isothermal/isoperibol microcalorimeter, flow microcalorimeter, potentiostats, turbidimeter, surface tensiometers, electrophoresis apparatus, ellipsometers, surface force analyzer, atomic force microscope, and Langmuir trough. Mine Surveying Laboratory: The Mine Surveying Laboratory houses nine total stations, six levels, and associated equipment including tapes, tripods, reflector prisms and rods. Mine Ventilation Laboratory: The facilities in the mine ventilation laboratory include three scaled wind tunnels, fans and various equipment for ventilation air monitoring including analog and digital manometers, methane detectors and anemometers. An additional tunnel is fully instrumented with fan control by PLC and injection and sampling ports for tracer gas experiments.

Research Centers

The Department of Mining and Minerals Engineering is home to two acclaimed research centers, i.e., Virginia Center for Coal and Energy Research (VCCER) and the Center for Advanced Separation Technologies (CAST). The centers offer students access to cutting-edge facilities and equipment in these specific focus areas. Center for Advanced Separation Technologies (CAST) - CAST is a consortium of five universities whose goal is to develop advanced technologies that can be used to produce clean solid, liquid and gaseous fuels from domestic energy resources in an efficient and environmentally acceptable manner. Current member institutions are Virginia Tech, West Virginia University, University of Kentucky, University of Utah and Montana Tech. CAST has funded more than 100 projects at seven universities. More information about this center can be obtained at www.cast.mining.vt.edu. Virginia Center for Coal and Energy Research (VCCER) - VCCER serves as an interdisciplinary study, research, information and resource facility for the Commonwealth of Virginia. VCCER involves five primary functions: (i) Research in interdisciplinary energy and coal-related issues of interest to the Commonwealth, (ii) Coordination of coal and energy research at Virginia Tech, (iii) Dissemination of coal and energy research information and data to users in the Commonwealth, (iv) examination of socio-economic implications related to energy and coal development and associated environmental impacts, and (v) assist Commonwealth of Virginia in implementing the Commonwealth's energy plan. The center has offices in the main Virginia Tech campus in Blacksburg, the National Capital Region Office

in Alexandria, and the Southwest Virginia Higher Education Center in Abingdon. More information about this center can be obtained at www.energy.vt.edu.

DEGREES OFFERED

MS Degree

Offered In (Blacksburg)

TOEFL

Paper: (550.0)

Computer: (213.0)

iBT: (80.0)

GRE

General: Verbal, Quantitative

Master of Science (MS): Successful MS students must complete 30 hours of university credit of which a minimum of 20 hours involve coursework and a maximum of 10 hours involve research. Students must also prepare and defend a written Thesis of their research findings during a Final Examination before an Examining Committee.

MEng Degree

Offered In (Blacksburg)

TOEFL

Paper: (550.0)

Computer: (213.0)

iBT: (80.0)

GRE

General: Verbal, Quantitative

Master of Engineering (MEng): Successful MEng students must complete 30 hours of applicable coursework and prepare and defend a written Project Report during a Final Examination before an Examining Committee.

PhD Degree

Offered In (Blacksburg)

TOEFL

Paper: (550.0)

Computer: (213.0)

iBT: (80.0)

GRE

General: Verbal, Quantitative

Doctor of Philosophy (PhD): Successful PhD students must complete 90 hours of university credit of which a minimum of 30 hours involve coursework and a maximum of 60 hours involve research. Students must also prepare and defend a written Dissertation of their research findings during a Final Examination before an Examining Committee. PhD candidates must pass a Qualifying Examination prior to the end of their first year of residency and must also pass a Preliminary Examination at least six months prior to taking the Final Examination.

GRADUATE COURSES (MINE)

MINE 5025:

Advanced Mining Design

Selected advanced design problems in mining including roof control, shafts, material handling, transportation, drainage, and ventilation.

Advanced work in creative quantitative design or ore milling and coal preparation plants.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

MINE 5026:

Advanced Mining Design

Selected advanced design problems in mining including roof control, shafts, material handling, transportation, drainage, and ventilation.

Advanced work in creative quantitative design or ore milling and coal preparation plants.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

MINE 5045:

Advanced Mineral Processing

The theory of reactions in flotation systems and application of physical chemistry to mineral beneficiation. Advanced studies in electrostatic and magnetic separation. Theory and application of differential gravity separations. Advanced studies in comminution, grinding systems, and coal preparation plant design, simulation, and control.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

MINE 5046:

Advanced Mineral Processing

The theory of reactions in flotation systems and application of physical

chemistry to mineral beneficiation. Advanced studies in electrostatic and magnetic separation. Theory and application of differential gravity separations. Advanced studies in comminution, grinding systems, and coal preparation plant design, simulation, and control. I,II

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

MINE 5084:

Stability of Rock Slopes

Factors affecting the stability and stabilization of rock slopes, geological site studies, mechanical properties of joints, calculations, influence of ground water, geometry, seismic effects, and case histories.

Credit Hour(s): 0 OR 3

Lecture Hour(s): 0 OR 2

Instruction Type(s): Lab, Lecture, Online Lecture

Instruction Type(s): Lab, Lecture, Online Lecture

Prerequisite(s): , GEOS 4414

Corequisite(s):

MINE 5094:

Particulate Process Modeling

Statistical and mechanistic approaches to modeling of mineral processing and other particulate systems. Population balance modeling of particulate systems. Representation of particle distributions. Numerical simulation techniques using the digital computer. II

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

MINE 5104:

Modeling and Monitoring the Behavior of Mining Systems

Advanced numerical modeling and monitoring methods. Emphasis on the use of numerical tools and monitoring methods in understanding the complex behavior of mining systems. Application of these tools to areas such as mineral processing, underground and surface structures, and material flow through independent project work. Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

MINE 5114:

Sustainable Development of Mineral and Energy Resources

Sustainable development in the context of mineral and energy resource extraction, including evolution and current status of principles, challenges, and best practices relative to various industry sectors and global regions; criteria for compatible engineering designs; and management strategies for stakeholder engagement and social license to operate. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

MINE 5204:

Reservoir Geomechanics

Assessment and production phase of oil and gas reservoir development; tectonic stress field; prediction of pore pressure; estimation of hydrocarbon heights and fault seal potential; determination of optimally stable well trajectories; changes in reservoir performance during depletion; effects of in situ stresses in petroleum reservoirs; and the applications to wellbore stability, critically stressed faults and fluid flow, and production induced faulting and subsidence. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

MINE 5205:

Coalbed Methane Reservoir Engineering

Reservoir engineering specific to coal beds for extraction of methane, including theory of gas flow in porous media, geomechanical effects of reservoir depressurization, reservoir simulation and production forecasting, drilling methods and patterns, and interactions with underground mine workings. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

MINE 5214:

Multicomponent Thermodynamics

Phase behavior of petroleum fluids; saturation pressure calculations; fluid phase equilibria; first and second law of thermodynamics for open systems; two-phase fluid properties; production engineering and separator calculation; and the applications to gas injection enhanced oil recovery and carbon dioxide sequestration in petroleum reservoirs. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

MINE 5224:

Flow and Transport in Petroleum Reservoirs

Basic principles of fluid dynamics; mass balance and Navier-Stokes equations; compressible flows; analytical solution of pressure diffusivity equations in petroleum reservoirs; Fourier analysis; fluid-solid interactions in proppant-supported hydraulic fractures; and the applications to petroleum production and geologic carbon sequestration. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

MINE 5234:

Numerical Modeling of Petroleum Reservoirs

Introduction to oil and gas reservoirs; basic Darcy-scale fluid mechanics in petroleum reservoirs; numerical solution of partial differential equations on the basis of finite difference methods; 1D, 2D, and 3D single-/two-phase flow simulations; transient and boundary-value problems; global challenges associated with energy and water; and the applications to water flooding and hydrocarbon production in petroleum reservoirs. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

MINE 5244:

Geophysical Investigation in Geoenergy Engineering

Basic principles on the acquisition and analysis of geophysical investigation data. Seismology for oil/gas exploration. Hydraulic fracture treatment monitoring. Underground mining and ground control monitoring. Carbon sequestration. Exploration of the use of common geophysical technologies and methods for characterization and monitoring activities associated with development and management of energy resources, primarily through examination of case studies and special topics related to remote sensing, ground-penetrating radar, electromagnetic sensing, well log analysis, and distributed sensing. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

MINE 5324:

Particulate Process Engineering

Advanced studies in process engineering as applied to particulate separation techniques in mineral processing and coal preparation. Collection, reconciliation, and interpretation of plant performance data. Process modeling as it relates to analysis and optimization of unit operations. Elements of process design including circuit analysis and flowsheet calculations. Focus on industrial problems. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

MINE 5904:

Project and Report

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research

Instruction Type(s): Research

Prerequisite(s):

Corequisite(s):

MINE 5944:

Seminar

Two written or oral presentations to be made by all graduate students on their thesis topics; also participation in all other graduate student, visiting lecturer, and faculty member presentations during their scholastic tenure. Required of all students for graduation. All graduate students in the department are required to enroll in the seminar for two semesters and to attend all the seminars.

Credit Hour(s): 1

Lecture Hour(s): 1

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

MINE 5974:

Independent Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Independent Study

Instruction Type(s): Independent Study

Prerequisite(s):

Corequisite(s):

MINE 5984:

Special Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

MINE 5994:

Research and Thesis

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research, Online Research

Instruction Type(s): Research, Online Research

Prerequisite(s):

Corequisite(s):

MINE 6034:

Surface and colloid chemistry as applied to the technology of froth flotation; surface energetics, thermodynamics of adsorption, electrification of interfaces, chemistry of surfactants, oxidation and reduction of sulfide minerals, electrochemistry of sulfide flotation systems, and hydrodynamics of bubble-particle adhesion.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

MINE 7994:

Research and Dissertation

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research

Instruction Type(s): Research

Prerequisite(s):

Corequisite(s):

OCEAN ENGINEERING

Eric Paterson, Head

Professors: Alan Brown; Robert Canfield; William Devenport; Rakesh Kapania; Eric Paterson; Mark Psiaki; Pradeep Raj; Shane Ross; Christopher Roy; Joseph Schetz; Craig Woolsey;

Associate Professors: Jonathan Black; Stefano Brizzolara; Olivier Coutier-Delgosha; Scott England; Mazen Farhood; Kevin Lowe; Mayuresh Patil; Michael Philen; Jonathan Pitt; Gary Seidel; Cornel Sultan; Gregory Young;

Assistant Professors: Colin Adams; William Alexander; Seongim Choi; Christine Gilbert; Mathieu Joerger; Luca Massa; Bhuvana Srinivasan; Kevin Wang; Heng Xiao;

Research Faculty: Nanyaporn Intaratep;

NAVSEA Professor of Naval Ship Design: Alan Brown;

Norris and Laura Mitchell Professor of Aerospace Engineering: Rakesh Kapania;

Rolls-Royce Commonwealth Professor of Marine Propulsion: Eric Paterson;

Fred D. Durham Endowed Chair Professor: Joseph Schetz;

Kevin Crofton Professor: Mark Psiaki;

Research Associate Professors: Aurelien Borgoltz;

Research Assistant Professors: Matthew Kuester;

Professor of Practice: Harry Artis;

Graduate Contact: gradadvise-g@vt.edu

Student Handbook:

https://www.aoe.vt.edu/content/dam/aoe_vt_edu/programs/graduate/forms/AOE_Graduate_P-P.pdf

Graduate Site: <https://www.aoe.vt.edu/graduate.html>

Master of Science Degree The Department of Aerospace and Ocean Engineering offers a Master of Science Degree in Aerospace Engineering and in Ocean Engineering. Each of these degrees has two options, a Master of Science with or without thesis. Although both degrees require the same number of credit hours for graduation, the thesis option requires some of these credits be devoted to a research project. The non-thesis option can be obtained by taking only course work, or it can include credits for a project and report. Such a project and report is generally not research oriented, but deals with other aspects of an engineering problem and may involve a team of students. In order to ensure that all our students can communicate with scientists and engineers outside their primary field of interest, all students take at least one course in the general areas of aerodynamics, structures, flight mechanics and control, and numerical methods. In addition, students in the non-thesis program are required to take additional courses in their area of study. Students in this program have the opportunity to work on advanced research projects in the three areas mentioned previously as well as in the interdisciplinary arena where familiarity with two or more disciplines is required. As a result many of our students are in a position to satisfy the rapidly growing demand for well rounded engineers and scientists. Students following the thesis route work with faculty that have both national and international reputations in their respective areas of research. These areas pose exciting new challenges to the students who have the opportunity to work closely with their faculty advisor on current problems. These problems reflect the latest interests in new advancements in science and technology by NASA, Navy, Air Force, and various aerospace and non-aerospace industries. Our masters students do significant hands-on research and often work in teams with other masters and Ph.D. students on wide-range of topics, some focused in a newly developing area, and some multidisciplinary in nature. These activities include state-of-the art research in aerodynamics, structures, flight dynamics and control, and multidisciplinary analysis and design. Students are encouraged to present their research results at conferences and in archival journals tied to industry and/or government or sponsored projects and include interaction with personnel and facilities from those organizations. The requirements for the degrees focused on applied physics or applied mathematics are slightly different from those of the other categories in that some required courses from the Aerospace and Ocean Engineering Department are replaced with others from either Physics or Mathematics respectively. These programs are specially tailored for students whose backgrounds are from outside the engineering environment and are interested in applying their skills to solving aerospace problems. Such programs encourage interaction with disciplines outside the usual engineering environment and result in new approaches to analyzing and solving problems.

SPECIAL FACILITIES

Research in Aerospace and Ocean Engineering poses exciting new challenges to the students who have the opportunity to work closely with their faculty advisor on current problems. These problems reflect the latest interests in new advancements in science and technology by NASA, Navy, Air Force, and various aerospace and non-aerospace industries. Our graduate students do significant hands-on research and

often work in teams with other graduate students on wide-range of topics, some focused in a newly developing area, and some multidisciplinary in nature. These activities include state-of-the-art research in aerodynamics, structures, flight dynamics and control, and multidisciplinary analysis and design. Students are encouraged to present their research results at conferences and in archival journals tied to industry and/or government sponsored projects and include interaction with personnel and facilities from those organizations. Research in Aerospace and Ocean Engineering poses exciting new challenges to the students who have the opportunity to work closely with their faculty advisor on current problems. These problems reflect the latest interests in new advancements in science and technology by NASA, Navy, Air Force, and various aerospace and non-aerospace industries. Our graduate students do significant hands-on research and often work in teams with other graduate students on wide-range of topics, some focused in a newly developing area, and some multidisciplinary in nature. These activities include state-of-the-art research in aerodynamics, structures, flight dynamics and control, and multidisciplinary analysis and design. Students are encouraged to present their research results at conferences and in archival journals tied to industry and/or government sponsored projects and include interaction with personnel and facilities from those organizations.

AOE 3D Print Laboratory

Students must send an email request to aoe-3dprint-g@vt.edu to gain access to submit printing jobs. This email will be used to create a user account and you will receive an invite to join GrabCAD Shop.

Hydro Elasticity Laboratory

The Hydroelasticity Laboratory is an experimental Fluid-Structure Interaction facility for Ocean structures in the Kevin T. Crofton Department of Aerospace and Ocean Engineering. The focus of this group is to understand fundamental physics of various fluid-structure interaction problems. One important problem that is currently being studied is of slamming impacts on high-speed planing craft, those vessels which are hydrodynamically loaded. The first phase of the experiment, which is shown in the photos, is of a flexible wedge drop experiment. Measurements are taken of hydrodynamic pressure, kinematics of the structure, and strain. Currently, the water tank is being redesigned to be larger in size to accommodate different types of experiments and to not restrict the jet resulting from the wedge impact. The new tank will also support flow visualization experiments. Another phase of the slamming experiment will be conducted in the Tow Tank facility and will allow for more degrees of freedom to be examined. Please contact Dr. Ikeda-Gilbert (cikeda@vt.edu) for more information.

Hydrodynamics Laboratory

(Randolph 33) Facilities: Drag-Reduction Test Facility, Water Tunnel

Marine Robotics Laboratory

(Randolph 15)

Ship Dynamics Lab

The VT AOE Ship Dynamics Laboratory provides space for cutting edge analytical, computational, and experimental research into vessel stability, capsizing, and quiescence. Amongst other resources, the laboratory is

home to two dual-processor high performance Linux workstations to enable computationally efficient simulation of seakeeping and strongly nonlinear capsizing behavior over large parameter ranges.

Towing Basin

Modeling ship resistance is done by towing a model in a towing basin. The basin, located in the basement of Norris Hall is made of reinforced concrete painted with a chemical and moisture resistant enamel. The width of the basin is 6 feet and the maximum water depth is 4 feet. The overall length of the basin is 98 feet but the first 4 feet and the last 24 feet are used for braking the carriage. The usable test length is then approximately 70 feet. There are two glass walled observation pits along the side of the tank, one located approximately in the middle of the test region and the other pit located at the starting end. The observation pit at the starting end is intended for use in the study of wave reflection and absorption. The carriage and rails were designed and constructed by the firm of Kempf and Remmers of Hamburg, Germany and were shipped in sub-assemblies to Virginia Tech. The allowable tolerance on rail height was 0.1mm. Wedges were used to give final straight alignment of each rail. The allowable tolerance on alignment was 0.2mm. Final alignment was done optically. After final adjustments in height were made, the space between the bearing plates and the bottom of the rail was filled with concrete. A 400 V DC motor drives the carriage through a gear reduction box. The DC power is supplied from a 220 V AC motor-generator set. A maximum speed of the carriage of 3.0 meters per second can be obtained. The carriage braking is done automatically using trips installed at both ends. An emergency brake button is also on the console. The brake is of the magnetic clutch type and brakes the DC motor directly. The brake is applied if power to the carriage is interrupted. Braking deceleration is 0.7 meter per second per second. Ocean Engineering undergraduate students perform two experiments in the basin. They test the resistance of both a surface ship and a submarine.

DEGREES OFFERED

MS Degree

Offered In (Blacksburg, Virtual)

TOEFL

iBT: (90.0)

GRE

General: Verbal, Quantitative, Analytical

Master of Science Requirements: Thesis and (Non-Thesis) 1. A minimum of 30 credit hours is required. For thesis students, up to 10 credit hours may be allotted for Research and Thesis (AOE 5994). For non-thesis students, up to 6 credit hours may be allotted for Project and Report (AOE 5904)[1]. 2. A minimum of 12 credit hours (15 for non-thesis) of graded course work numbered 5000 and higher must be included in the Plan of Study. These credit hours do not include the AOE

Seminar (AOE 5944), Research and Thesis (AOE 5994) hours, or Project and Report (AOE 5904) hours. 3. A maximum of 6 credit hours (9 for non-thesis) of 5974 and 5984 is allowed. 4. A maximum of 6 credit hours of approved 4000 level course work is allowed. 5. Up to 50% of the courses on the Plan of Study may be transferred from a graduate program at another institution, subject to the approval of the Advisory Committee. Substitution of a transferred course for a specific required course is subject to the approval of the Graduate Program Director or a designee, usually the responsible instructor. Each transferred course must have a grade of B (3.0/4.0) or better. 6. All Ocean Engineering M.S. candidates are required to take: AOE 4404, Applied Numerical Methods; AOE 5074, Advanced Ship Structural Analysis[3]; AOE 5104, Advanced Aero and Hydrodynamics; and AOE 5334, Advanced Ship Dynamics. In addition, thesis (non-thesis) students must take 9 (18) hours of approved electives, and non-thesis students must take 6 units of "Project and Report" or complete a 6 unit Capstone Naval Ship Design Project (AOE 5315 and AOE 5316). Electives for thesis students are determined in consultation with the Advisory Committee Chair. Non-thesis ocean engineering students must take two of the following courses: AOE 4024, An Introduction to the Finite Element Method; AOE 4264, Principles of Naval Engineering; AOE 5034, Mechanical and Structural Vibrations; AOE 5084, Submarine Design; AOE 5144, Boundary Layer Theory and Heat Transfer; AOE 5304, Advanced Naval Architecture; AOE 5305, Marine Engineering; AOE 5314, Naval Ship System Design and Effectiveness[4]; AOE 5374, Rationally-Based Design of Ocean Structures; AOE 5434G, Advanced Introduction to Computational Fluid Dynamics; AOE 5444G, Advanced Dynamics of High-Speed Craft; AOE 5454, Advanced Aerospace and Ocean Engineering Instrumentation; and AOE 6145, Computational Fluid Dynamics. 7. If a student has previously taken any of the required courses listed above or equivalent, while a Virginia Tech undergraduate or a student elsewhere, that course must be replaced with another course approved by the Advisory Committee. A student will not be allowed to repeat a Virginia Tech course (or an equivalent course from another institution) for a grade. A required AOE course can only be replaced with another AOE course. [1] Non-thesis Ocean Engineering M.S. candidates may take both AOE 5315-5316: Naval Ship Design to meet the 6 unit Capstone Naval Ship Design Project in place of 6 units of AOE 5904: Project and Report. [2] It is strongly recommended that students who wish to take AOE 6744, first take AOE 5744, Linear Systems Theory or an equivalent course on linear, time-varying systems. [3] If AOE 4274: Computer-Based Design of Ocean Structures has already been taken, then one of the following two courses must be substituted: AOE 5024: Vehicle Structures or AOE 5374: Rationally-Based Design of Ocean Structures. [4] It is strongly recommended that students who wish to take AOE 5314: Naval Ship System Design and Effectiveness, first take AOE 4264: Principles of Naval Engineering.

GRADUATE COURSES (AOE)

AOE 5024:

Vehicle Structures

Exact and approximate methods for analysis and design of aerospace and marine structures. Stresses, strains, constitutive equations, boundary value problems, and two-dimensional elasticity; torsion; variational methods; virtual work and energy principles; structural mechanics theorems; traditional approximate methods; and laminated plates.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

AOE 5034 (ESM 5304):

Mechanical and Structural Vibrations

Free and forced vibrations of single-degree-of-freedom systems, multi-degree-of-freedom systems, continuous systems including strings, rods, bars, and beams. Natural frequencies and modes. Rigid Body modes. Proportional and nonproportional damping. Response to harmonic, periodic, and nonperiodic excitations. Solutions by modal analysis, direct integration and Fourier Series. Approximate methods including assumed modes and the Rayleigh-Ritz method. Advanced topics chosen by instructor.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

AOE 5054 (ESM 5454):

Elastic Stability

Stability of elastic structural components under conservative loads; precise definitions of stability; energy approaches; Rayleigh-Ritz and Galerkin methods; and applications to column, arches, plates, and shells.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): AOE 3124 (UG) OR CEE 3404 (UG)

Corequisite(s):

AOE 5064:

Structural Optimization

Structural optimization via calculus of variations. Application of techniques of mathematical programming to optimize trusses, beams, frames, columns, and other structures. Sensitivity calculation of structural response. Approximation techniques and dual and optimality criteria methods. A background in optimization is necessary.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

AOE 5074:

Advanced Ship Structural Analysis

Analysis of plate bending, buckling, and ultimate strength using computational tools and methods. Calculation of elastic buckling of stiffened panels. Eigenvalue methods for buckling and vibration. Incremental plastic collapse; other progressive collapse. Ultimate strength of large structural modules due to combined loads. Introductory level finite element analysis. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

AOE 5084:

Submarine Design

Application of engineering disciplines to the design of a steam turbine propelled nuclear submarine. The disciplines involved are fluid mechanics, solid state mechanics, structures, machine design, thermodynamics and heat transfer.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

AOE 5104:

Advanced Aero and Hydrodynamics

Vector analysis concepts; fluid stress and strain, kinematics of fluid flows including vorticity; dynamics of inviscid incompressible flow; and potential flow theory with applications to lifting and non-lifting bodies.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

AOE 5114:

High Speed Aerodynamics

Aerothermodynamic phenomena and shock waves. Linearized subsonic

and supersonic flow past planar surfaces and bodies of revolution.

Theory of transonic aerodynamics including study of mixed flow.

Similarity laws. Mathematical representation of inviscid compressible flows in equilibrium. Potential function, stream function, rotationality and geometrical considerations. Method of characteristics applied to hyperbolic flow fields. Discussion of techniques for solution of elliptic flow fields.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): AOE 3114 (UG)

Corequisite(s):

AOE 5124:

Aero and Hydroacoustics

Aeroacoustics for students familiar with the foundations of fluid dynamics. Fundamental theories of aeroacoustics, including Lighthill's analogy, the Ffowes-Williams-Hawkings equation and Goldstein's equation. Mathematical methods needed to and apply these theories, including correlation and spectral methods for turbulent flows.

Applications include the prediction of leading and trailing edge noise are taught. Relevant experimental methods, including facilities, corrections, instrumentation, signal processing and phased microphone arrays.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): AOE 5104

Corequisite(s):

AOE 5135 (ME 5135):

Vehicle Propulsion

Aerothermodynamics of gas turbines and rockets: cycle analysis of turbojets, turbofans, prop fans, and turbo props. Analysis of ramjets and scramjets. Performance of inlets, combustors, and nozzles. Elementary theory of turbomachinery. Liquid and solid propellant chemical rockets. Electrostatic, electromagnetic, and electrothermal propulsion. Integrated rocket-ramjet. Fuels and propulsion systems for future transportation system.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): AOE 3114 (UG), ME 3134 (UG)

Corequisite(s):

AOE 5144:**Boundary Layer Theory and Heat Transfer**

Conservation equations and constitutive relations, exact Navier Stokes solutions; boundary layer approximation and special solutions; approximate methods; compressibility and heat and mass transfer effects; and numerical methods and simple turbulence models.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): AOE 5104

Corequisite(s):

AOE 5154:**Data Analysis in Fluid Dynamics**

Data analysis techniques and their role in fluid dynamics research. Fundamental tools for statistical analysis of random processes. Ways to obtain physical meaning from fluid dynamics data. Techniques for single-point statistics and correlation-based, multi-point statistics of data fields. Hypothesis-driven study of complex flow phenomena. Analysis of unsteady and turbulent flow emphasized. Pre: Graduate Standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

AOE 5164:**Fluid-Structure Interaction**

Review of essential elements of elastic vibration and basic fluid mechanics; hydroelasticity based on potential flow theory; acoustic-structure interaction; dynamic aeroelasticity of airfoils; analytical solution of selected 1- and 2-D model problems; overview of computational models and methods for nonlinear fluid-structure interaction problems (e.g., partitioned and monolithic procedures, arbitrary Lagrangian-Eulerian, immersed/embedded boundary, interface tracking). Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

AOE 5174 (ECE 5174):**Introduction to Plasma Science**

Underlying physical processes and basic computational techniques for laboratory, space, and technological plasma environments including single particle motion, fluid and kinetic theory of plasmas, plasma waves and instabilities, diffusion and resistivity, and nonlinear effects. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

AOE 5204:**Vehicle Dynamics and Control**

Relevant rigid body kinematics and dynamics fundamentals for vehicles such as aircraft, spacecraft, and ships. Provides foundation for advanced courses and research on dynamics and control of vehicles. Review of particle motion and application to aircraft performance and satellite orbital mechanics. Rigorous modeling of rotational and translational motion of rigid bodies. Linearization of equations of motion for stability analysis, modal analysis, control system synthesis, with introduction to classical control system concepts. Sensors and actuators commonly used on vehicles. Specific examples from aircraft, missiles, spacecraft, rockets, ships, and submersibles.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): AOE 3134 (UG), AOE 3234 (UG) OR AOE 4140 (UG)

Corequisite(s):

AOE 5234:**Orbital Mechanics**

Lagranges equations of motion, two-body problem, conic sections, Keplers laws, orbit determination. Multi-body problems and integrals of motion. Fundamentals of perturbation theory, variation of parameters, and Lagranges planetary equations. Regularization and alternative formulations of equations of motion.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

AOE 5244:**Optimization Techniques**

Ordinary minimum problems with constraints. The classical multiplier method, descent methods, and quasi-Newton methods. Optimal control and the maximum principle. Second-order necessary conditions.

Singular control. Continuous gradient methods, conjugate gradients.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): AOE 3134 (UG), MATH 4564 (UG)

Corequisite(s):

AOE 5304:

Advanced Naval Architecture

Engineering analysis methods for evaluating the hydrostatic, hydrodynamic, and structural characteristics of surface ships and submarines. Methods employed in ship design include analytical, statistical, and experimental approaches. Both hull and propulsor analysis techniques are covered.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

AOE 5314:

Naval and Marine Engineering Systems Design

Concepts, theory, and methods for the engineering, design, integration, and assessment of ship mechanical, electrical, fluid and naval systems.

Description and functional physics of system components, system architecture, and the modeling of system effectiveness for multidisciplinary and multi-objective design optimization. System integration, interfaces, and analyses considering ship arrangements, signatures, system deactivation diagrams and vulnerability, reliability, maintenance, system power, shock and weapons effects and damage control.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): AOE 5324

Corequisite(s):

AOE 5315:

Naval Ship Design

Capstone naval ship design concept exploration including the study and application of the system engineering process to the simultaneous

development of naval ship requirements, selection of ship technologies, and definition of a baseline naval ship design. Hullform, machinery, ship synthesis and balance, metrics (including Overall Measure of Effectiveness, technology risk, and cost) and design optimization in the context of a naval ship design project.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): AOE 5304, AOE 5314, AOE 5334, AOE 5074

Corequisite(s):

AOE 5316:

Naval Ship Design

Development of a naval ship baseline design including hullform, combat systems, topside arrangements, internal subdivision and tankage, power and propulsion, auxiliary machinery, general arrangements, machinery arrangements, human systems, structural design, assessments of intact and damage stability, shock and survivability, weights, space, seakeeping, cost, risk, and overall balance and feasibility.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): AOE 5315

Corequisite(s):

AOE 5324:

Principles of Naval Engineering with Applications

Basic functional principles and theory for naval engineering systems and system engineering processes. Particular emphasis is given to: naval missions; combat system performance including radar; underwater acoustics and sonar; ballistics; weapon propulsion and architecture; weapons effects; ship survivability including underwater explosion and shock waves; surface ship and submarine hydrostatics, balance and feasibility analysis; and total ship integration. Pre: Graduate Standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

AOE 5334:

Advanced Ship Dynamics

Derivation of the equations of motion of a ship; waves and wave forces on structures; description of wave statistics and spectral representation

in a given sea state; ship response in regular waves; ship response in random waves.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): AOE 3234 (UG), MATH 4564 (UG)

Corequisite(s):

AOE 5434G:

Advanced Introduction to Computational Fluid Dynamics

Euler and Navier-Stokes equations governing the flow of gas and liquids.

Mathematical character of partial differential equations. Discretization approaches with a focus on the finite difference method. Explicit and implicit solution techniques and their numerical stability. Introduction to verification, validation, and uncertainty quantification for computational fluid dynamics predictions. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

AOE 5444G:

Advance Dynamics of High Speed Marine Craft

Study of the dynamics of high-speed craft, including surface effects ships, hydrofoil vessels, semi-displacement monohulls and catamarans, and planning vessels. Pre-requisite: Graduate Standing required

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

AOE 5464:

Combustion Chem & Diag

Combustion chemistry and laser-based combustion diagnostics from a fundamental, microscopic level. Statistical thermodynamics, molecular collisional models, chemical kinetics, reaction mechanisms for combustion systems, spectroscopy (absorption, Rayleigh, Raman, and Laser Induced Fluorescence), and diagnostics for measuring various combustion properties. Practical implementation and industrial applications. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

AOE 5604:

Modeling Composites Damage

Algorithms, techniques and tools applied in multiscale modeling of damage and failure in composite materials. Continuum level models, mesoscale models, and atomistic models. Analytic and computational techniques for capturing damage effects and conducting length scale transitions. Homogenization techniques, multiple scale expansion, finite element analysis, continuum damage models, cohesive zone models, dislocation dynamics, particle methods, and molecular statics and dynamics. Role of mesh-independent and meshless methods in modeling damage evolution. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

AOE 5614:

Modeling Multifunct Composites

Algorithms, techniques and tools applied in multiscale modeling of multifunctional composite materials. Continuum mechanics mathematical models for mechanical, thermal, and electromagnetic behaviors and linear and nonlinear couplings between them in active materials. Origins of coupled material response in active materials. Analytic and computational micromechanics to predict macroscale multifunctional composite properties based on active material constituents at the microscale.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

AOE 5654 (ECE 5164):

Intro to Space Science I

Describes the space environment from the sun to the earth's upper atmosphere. Fundamental concepts in space plasma physics will be presented, as needed, throughout the course. Numerous examples of observations and data will be utilized to illustrate the environment and its dynamic variability. An emphasis will be placed on the practical impacts

of this environment and its dynamic variability. An emphasis will be placed on the practical impacts of this environment (space weather) on modern technologies such as solid state devices, satellite technology, communication and global navigation systems.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s): ECE 5105

AOE 5664:

Upper Atmosphere and Ionosphere

Fundamental concepts of solar-terrestrial physics; interaction of Earth's upper atmosphere and space environment with spacecraft; upper atmospheric composition, radiation, photochemistry and energy balance; structure of the upper atmosphere; impacts of transport and dynamics on the upper atmosphere; ionospheric composition, production and loss and its relation to Chapman theory; ionospheric structure; impacts of ionospheric electrodynamics; impacts of geomagnetic storms on the upper atmosphere and ionosphere; radio wave propagation; comparisons to other planets; details of atmospheric and ionosphere instrumentation. Pre: Graduate standing in Engineering.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

AOE 5734 (ECE 5734) (ME 5584):

Convex Optimization

Recognizing and solving convex optimization problems. Convex sets, functions, and optimization problems. Least-squares, linear, and quadratic optimization. Geometric and semidefinite programming. Vector optimization. Duality theory. Convex relaxations. Approximation, fitting, and statistical estimation. Geometric problems. Control and trajectory planning. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

AOE 5744 (ME 5544) (ECE 5744):

Linear Systems Theory

Advanced introduction to the theory of time-varying and time-invariant linear systems represented by state equations; solutions of linear systems, uniform stability and other stability criteria, uniform observability and controllability, state feedback and observers.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECE 4405 (UG) OR ECE 4405 OR ECE 4624 (UG) OR ECE 4634 OR ECE 4634 (UG) OR ECE 4634 OR ME 4504 (UG) OR ME 4504 OR AOE 4004 (UG) OR AOE 4004

Corequisite(s):

AOE 5754 (ECE 5754) (ME 5554):

Applied Linear Systems

Develop an applied understanding of state-space representations for linear time invariant multi-input multi-output dynamic systems in both time domain and frequency domain. Introduction to modern state-space control methods; state feedback and output feedback. Realistic design problems with numerical simulations of practical implementations.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECE 4405 (UG) OR ECE 4405 OR ECE 4624 (UG) OR ECE 4624 OR ECE 4634 (UG) OR ECE 4634 OR ME 4504 (UG) OR ME 4504 OR AOE 4004 (UG) OR AOE 4004

Corequisite(s):

AOE 5764 (ME 5564) (ECE 5764):

Applied Linear Control

Analysis and design of sampled-data systems, extraction of discrete-time dynamic models from experimental data, and implementation of dynamic compensators on digital processors. In-depth design experience with LQR optimal control and an introduction to Kalman filtering. Realistic design problems with numerical simulations of practical implementations.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): AOE 5744 OR AOE 5754 OR ME 5554 OR ME 5544 OR ECE 5744 OR ECE 5754

Corequisite(s):

AOE 5774 (ECE 5774) (ME 5574):

Nonlinear Systems Theory

Introduction to the theory of systems of coupled, nonlinear, time-varying ordinary differential equations: existence and uniqueness of solutions; continuous dependence on parameters; stability of equilibria and stability analysis techniques; input-to-state stability; input-output stability; nonlinear design techniques including input-state and input-output feedback linearization, backstepping, and sliding mode control.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECE 4405 (UG) OR ECE 4405 OR ECE 4624 (UG) OR ECE 4624 OR ECE 4634 (UG) OR ECE 4634 OR ME 4504 (UG) OR ME 4504 OR AOE 4004 (UG) OR AOE 4004

Corequisite(s):

AOE 5784:

Model-Based Estimation and Kalman Filtering

Modeling of estimation problems including batch and dynamic problems; stochastic linear and nonlinear dynamic system models including Markov process models; batch nonlinear least-squares estimation; linear Kalman filtering and smoothing algorithms for dynamic problems; square-root information filtering and smoothing; nonlinear Kalman filtering, including the extended Kalman filter, the unscented Kalman filter, and particle filters; covariance analysis; filtering applications. Co: 5744 or 5754 or ECE 5744 or ME 5544 or ECE 5754 or ME 5554.

Credit Hour(s): 4

Lecture Hour(s): 4

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

AOE 5844 (CEE 5844):

Wave Mechanics

Linear wave theory including boundary value problems, wave transformation in shallow waters, long waves, and engineering properties of waves. Introduction to nonlinear wave theories. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

AOE 5894:

Final Examination

NONE

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

AOE 5904:

Project and Report

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research, Online Lecture, Online Research

Instruction Type(s): Research, Online Lecture, Online Research

Prerequisite(s):

Corequisite(s):

AOE 5914:

Autonomous Systems Seminar

Weekly technical presentations from local and visiting scholars on current topics related to the theory, design and development, and application of autonomous vehicle systems. Pre-Requisite: Graduate Standing required.

Credit Hour(s): 1

Lecture Hour(s): 1

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

AOE 5944:

Seminar

Discussion of current research topics in Aerospace and Ocean Engineering by local and visiting scholars. This course cannot be used to fulfill the minimum requirements of 30 hours toward the Masters Degree or 90 hours toward the Ph.D. Degree in Aerospace and Ocean Engineering. May be repeated.

Credit Hour(s): 1

Lecture Hour(s): 1

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

AOE 5974:

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Independent Study, VI

Instruction Type(s): Independent Study, VI

Prerequisite(s):

Corequisite(s):

AOE 5984:

Special Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

AOE 5994:

Research and Thesis

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research, Online Research

Instruction Type(s): Research, Online Research

Prerequisite(s):

Corequisite(s):

AOE 6024:

Aeroelasticity

Discussion of the aeroelastic phenomena including flutter, divergence, control surface effectiveness, and lift redistribution; and introduction to traditional and modern methods of analysis and remedies for aeroelastic problems of flight vehicles.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): AOE 5034, AOE 5104, AOE 5214

Corequisite(s):

AOE 6064:

Reliability-Based Design Optimization

Analyze uncertainties associated with mechanical and structural design.

Methods to model various uncertainties in a design using stochastic expansions and other probabilistic analysis tools. Computation of safety index and structural reliability using efficient techniques for implicit

functions. Optimize designs under uncertainty.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): AOE 5064 OR AOE 5734 OR ECE 5734 OR ISE 5406 OR MATH 5485 OR ME 5584

Corequisite(s):

AOE 6114:

Transonic Aerodynamics

Basic features of transonic flows, similarity methods, and hodograph methods. Major emphasis on finite difference procedures including type dependent relaxation procedures for potential flows and time asymptotic Euler solutions. Grid generation methods, inverse design procedures, unsteady flow, wind tunnel/wall interference, and shock wave/boundary layer interactions.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): AOE 3114 (UG), AOE 4404 (UG), AOE 5144

Corequisite(s):

AOE 6124:

Hypersonic Aerodynamics

Theory of inviscid hypersonic flows; blunt body and Newtonian aerodynamics; nonlinear small disturbance theory; and approximate methods and comparisons with experiment. Viscous hypersonic flow theory; skin friction and heat transfer on blunt and slender bodies; and vorticity, entropy layer, and viscous-inviscid inter-action effects.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): AOE 5114

Corequisite(s):

AOE 6145:

Computational Fluid Dynamics

Computational methods for incompressible, compressible, and viscous fluid flows. Theoretical and numerical developments for wave equation, heat equation, Poissons equation, and Burgers equation. Applications to inviscid subsonic, transonic, and supersonic flows, viscous boundary layer, Navier Stokes, thin layer equations, and grid generation techniques.

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): AOE 3114 (UG), AOE 4404 (UG), AOE 5104

Corequisite(s):

AOE 6154:

Turbulent Shear Flow

Advanced treatment of the physical phenomena of turbulent boundary layers, jets, wakes, and duct flows; coherent structures; entrainment, bursting, vortex dynamics; and unsteady, wall, and freestream turbulence effects.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): AOE 5144 (UG)

Corequisite(s):

AOE 6174 (ECE 6174):

Computational Plasma Dynamics

Computational techniques for investigating processes in plasmas over a broad range of spatial and temporal scales. Investigation of physical processes including electrodynamics, waves and turbulence, space propulsion, spacecraft environmental effects and various laboratory applications. Computational techniques including full Particle-in-Cell (PIC), hybrid (fluid-electron, PIC ion), magnetohydrodynamics MHD and two-fluid methods.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECE 5174 OR AOE 5174

Corequisite(s):

AOE 6204:

Adv Vehicle Dynamics & Control

Topics in the dynamics and control of systems including airplanes, helicopters, spacecraft, and structures. Physics and data-based modeling from the control system designers perspective. Structure of the control-oriented equations of motion in relation to robust control design. Bio-inspired design.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): AOE 5204

Corequisite(s):

AOE 6234:

Advanced Orbital Mechanics

Canonical dynamics and applications to the two and three body problems. Classical and canonical variation of parameter equations of motion. Forces influencing Earth satellite motion are surveyed. Applications to Earth satellite motion. Additional topics from resonance, stability, periodic motion, numerical integration, and orbit determination.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): AOE 5234

Corequisite(s):

AOE 6254 (ESM 6254):

Turbulence Modeling and Simulation

In-depth study into the modeling and simulation of turbulent flows. Derivation of exact equations describing turbulent flows along with various approaches to turbulent closure. Turbulence modeling via algebraic, RANS, and Reynolds stress models. Turbulence simulation via DNS, LES and hybrid RANS/LES approaches and analysis of results. Turbulence compressibility effects, body forces, boundary conditions, wall functions, sub-grid modeling approaches, turbulence anisotropy and stress invariants, and realizability. Strengths and weaknesses of the different modeling and simulation approaches. Role of numerics in different modeling approaches. Pre: Graduating standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

AOE 6314:

Advanced Dynamics

Fundamental concepts of analytical mechanics, variational principles, Lagranges equations, rigid-body kinematics and dynamics, Euler parameters, quasi-coordinates, Eulers equations, gyroscopic systems, Hamilton-Jacobi equation, transformation theory, introduction to optimal control theory, advanced concepts in stability theory.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

446 Prerequisite(s): ESM 5314

Corequisite(s):

AOE 6434 (ME 6434):

Computational Fluid Dynamics and Heat Transfer

Overview of numerical methods used in the study of computational fluid dynamics (CFD) and heat transfer. Spatio-temporal finite-difference, finite-volume discretizations, solution of linear systems with direct and iterative methods, algorithms for solving the Navier Stokes and energy equations, and turbulence modeling. Applications to inviscid subsonic, transonic, and supersonic flows and viscous boundary layer. Theory reinforced with hands on programming assignments and the application of commercial CFD packages to select problems.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ME 5404, ME 5314, ME 5104

Corequisite(s):

AOE 6444 (CS 6444) (ME 6444):

Verification and Validation in Scientific Computing

Applicable to scientific and engineering models described by partial differential or integral equations. Software engineering, code verification, and the method of manufactured solutions for generating exact solutions. Estimation of numerical approximation errors in scientific computing. Design and execution of experiments for model validation and model accuracy assessment. Propagation of aleatory and epistemic uncertainty through models. Estimation of total prediction uncertainty in scientific computing simulations. Graduate Standing required

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

AOE 6744 (ECE 6744) (ME 6544):

Linear Control Theory

Advanced introduction to the theory of optimal control of time-varying and time-invariant linear systems; Solutions to the linear-quadratic regulator, optimal filtering, and linear-quadratic-gaussian problems; Robustness analysis and techniques to enhance robustness of controllers.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECE 5744 OR ECE 5754 OR ME 5544 OR ME 5554 OR AOE 5744 OR AOE 5754

Corequisite(s):

AOE 6774 (ISE 6574) (ECE 6774) (ME 6574):

Adaptive Control Systems

Introduction to the theory and methodology used to design adaptive controllers for uncertain systems, addressing issue such as input constraints, disturbance rejection, partial measurements, and robustness.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): (ECE 5774, ECE 5744) OR (ME 5544, ME 5574) OR (AOE 5774, AOE 5744)

Corequisite(s):

AOE 6974:

Independent Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Independent Study, VI

Instruction Type(s): Independent Study, VI

Prerequisite(s):

Corequisite(s):

AOE 6984:

Special Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

AOE 7994:

Research and Dissertation

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research, Online Research

Instruction Type(s): Research, Online Research

Prerequisite(s):

447 Corequisite(s):

ARCHITECTURE

Aaron Betsky, Program Director

Emeriti Faculty: Salahuddin Choudhury; Edward Dorsa; Dayton Egger; Jaan Holt; Humberto Rodriguez-Camilloni; Hans Rott;

Professors: Kathryn Albright; Markus Breitschmid; Donna Dunay; Robert Dunay; Paul Emmons; Michael Ermann; James Jones; Susan Piedmont-Palladino; Robert Schubert; Mehdi Setareh; Frank Weiner; Joseph Wheeler;

Associate Professors: James Bassett; Hilary Bryon; Mario Cortes; David Dugas; Kay Edge; Marcia Feuerstein; William Galloway; Howard Gartner; Elizabeth Grant; William Green; Aki Ishida; Shelley Martin; Margarita McGrath; Vance Pittman; Heinrich Schnoedt; Gregory Tew; Steven Thompson; Lisa Tucker;

Assistant Professors: Edward Becker; Matthew Wagner;

G. Truman Ward Endowed Professor in Architecture: Donna Dunay;

T.A. Carter Professor in Architecture: Robert Dunay;

Patrick and Nancy Lathrop Professor Emeritus: Dayton Egger; Jaan Holt;

Graduate Coordinator: vaughnw@vt.edu

School of Architecture + Design: <http://archdesign.vt.edu/architecture/>

Master of Architecture The graduate curriculum is structured to allow flexibility and to accommodate diverse student needs. This is accomplished by offering a combination of choices of studies available within the various program options. The M.Arch. 2 and 3 options result in the conferring of a first professional degree, fully accredited by the National Architectural Accrediting Board. For details see <http://archdesign.vt.edu/architecture/Central> to the academic structure of these several options is the design laboratory. The various design laboratories are oriented toward formulation and resolution of design questions at a broad range of scales. In addition to fostering a mastery of the design process, the design laboratory is intended to cultivate a foundation for design through the study of concepts and principles of form generation, through education of an environmental awareness and aesthetic judgment, through study of the syntax of architectural language, and through the development of technical knowledge of the processes of fabrication and construction. These learning-oriented laboratories encourage the use of previously acquired knowledge, skills, and experience gained in the architectural profession and in other academic disciplines.

SPECIAL FACILITIES

The Architecture programs are housed on the Blacksburg campus in Cowgill Hall and Burchard Hall and are supported by research shop facilities located at the Research and Demonstration Facility and the Advanced Design and Construction Facility. The Washington Alexandria Architecture Center [WAAC] is located in historic old town Alexandria, Virginia and is a part of the university's National Capital Region facilities. Most program options are offered at the WAAC except the M.Arch 3 option. Students may also elect to spend a semester of study abroad at the university's Steger Center for International Scholarship in Riva San Vitale, Switzerland where we have a residential studio each spring.

Advanced Design and Construction Facility

The Advanced Design and Construction facility is a new 5,000 square foot building scheduled for occupancy Spring of 2019. Situated adjacent to the Research and Demonstration Facility in the Plantation Road Research complex, this laboratory is an integral part of academic and research programs, supporting building prototype construction and testing at a range of scales from components through full-scale building assemblies. This flexible laboratory is outfitted with an overhead gantry crane and a wide complement of state-of-the-art computer-aided fabrication tools. Intelligent buildings, advanced material research, and robotic-assisted assembly with an emphasis on testing and evaluation are among the types of projects taking place here.

Burchard Hall

Burchard Hall provides studio space for the architecture and industrial design programs of the School of Architecture + Design, faculty office space, and workshops for ceramics, plaster, graphics, and computer/digital media. The building was constructed underground -- with four pyramidal skylights illuminating studio spaces below -- to preserve Cowgill Plaza, a popular meeting place and campus thoroughfare. A stairway leads from a kiosk in the plaza to the subterranean offices and studio space.

Cowgill Hall

Cowgill Hall houses the School of Architecture + Design administrative offices, as well as the College of Architecture and Urban Studies Dean's offices. In addition, it provides space for faculty offices, classrooms, and undergraduate and graduate architecture studios. The lobby of Cowgill Hall serves as the school's principal exhibition space. Literature resources are also housed on the ground floor of Cowgill Hall in the Art and Architecture Library, a branch of the University's Newman Library. Shop facilities, located adjacent to the building, provide woodworking and metalworking equipment; a ceramic workshop allows creative and analytical work with clay and plaster; a graphics workshop includes equipment for etching, embossing, and serigraphy; and there are five darkrooms plus film, video, and other photographic facilities.

Research and Demonstration Facility

Located at the end of Plantation Road, approx. 1 mile from the center of the Virginia Tech campus in Blacksburg, the Research + Demonstration Facility provides approximately 11,000 square feet of space, including a design studio, a seminar/lecture room, workshops, a testing facility for wall constructions, and testing laboratories for indoor air quality. Since its dedication in the Spring of 1994, the Research and Demonstration Facility, built through a series of construction research projects sponsored by the National Concrete Masonry Association and other industry groups, has become an integral part of the School's academic and research programs, supporting prototype construction and testing at a range of scales from components through full-scale building

assemblies. The surrounding University-owned land is suitable and available for the construction of building prototypes for testing in an exterior environment.

DEGREES OFFERED

MS Degree

Offered In (Blacksburg, National Capital Region)

TOEFL

Paper: (577.0)

Computer: (233.0)

iBT: (90.0)

Master of Science in Architecture (offered in Blacksburg and at the Washington Alexandria Architecture Center in the NCR) The Master of Science in Architecture program offers the opportunity for advanced study and research in specialized areas related to building design, construction, and operations over a broad range of scales, providing the basis for diverse career paths and/or entry into a Ph.D.- level program. The M.S. is not directed toward professional licensing and therefore is not accredited by the NAAB as a "first professional degree." While an undergraduate degree in architecture or a related field is not required, applicants must demonstrate relevant background and experience, as well as capabilities for undertaking advanced academic study. The Master of Science program allows a student to conduct a research-based program of study which can be expected to contribute to the body of knowledge in the design and building professions, and may lead to future study in the doctoral program, where advanced standing may be awarded for acceptable graduate credits earned at the master's level. Students will develop their own programs of study in cooperation with appropriate faculty and in consideration of the courses and facilities available. A brief description of the available research concentrations follows: Building Science: Studies in the category of Building Science focus on various issues over a broad range of scales and may concentrate on the following (or other) areas: energy and building design; mechanical systems and large buildings; lighting and daylighting; natural ventilation and air flow; indoor air quality; acoustics and theater design; and building structure, assembly, and/or economics. Interior Design: This concentration allows those with professional degrees in Interior Design or closely related areas the opportunity for advanced research which is expected to add to the body of knowledge in the discipline of Interior Design. Potential research areas include design practice, history of interiors, computer applications in interior design, and environmental factors related to interiors. Urban Design: This concentration allows students an opportunity to engage in urban design research, addressing the design of safe, healthy, and sustainable urban environments. Emphasis is on the physical form of cities and the complex forces that shape them. Focused on the general underlying themes of security, resilience, health, and sustainability, possible research areas include but are not limited to mobility and infrastructure, conservation and preservation, and urban places and dwellings. The Urban Design program is housed in the facilities of the Washington - Alexandria Architecture Center (WAAC) in Alexandria, VA. The Master of Science degree is awarded upon satisfactory completion of an approved plan of study of at least 36 credit hours, normally including a thesis representing up to 10 hours of the total hours required.

MArch Degree

Offered In (Blacksburg, National Capital Region)

TOEFL

Paper: (577.0)

Computer: (233.0)

iBT: (90.0)

Master of Architecture (offered in Blacksburg and at the Washington Alexandria Architecture Center in the NCR for all or a portion of the of the degree) First Professional Degree Programs M.Arch.2, Advanced Professional Studies: An Advanced Professional Studies option (M.Arch.2) is offered for the student who has previously obtained a four-year, pre-professional baccalaureate degree in architecture. The first year of study continues the student's professional building design education and related technical and history/theory studies. The second year is reserved for preparation of a design thesis demonstrative of the student's academic accomplishment and professional potential. Students in this program typically complete 54 (min.) credit hours, normally requiring at least two academic years (four semesters) of study. Students in the M.Arch.2 program may elect to enroll at the Washington-Alexandria Center for all or a portion of their required studies and/or may spend a semester participating in the Europe Study Abroad Travel Program or in residence at the Center for European Studies and Architecture (CESA) in Riva San Vitale, Switzerland. M.Arch.3, Comprehensive Professional Studies A Comprehensive Professional Studies option (M.Arch.3) is provided for graduate applicants with degrees in fields other than architecture. The student is presumed to have undertaken little or no concentration in architecture prior to enrollment in the program. In addition to the 54 (min.) graduate credit hours required for the degree, students in the M.Arch.3 option complete 27 credit hours of qualifying year academic work, engaging in studies to provide a foundation of environmental design experiences and to promote a basic understanding of the discipline. Upon successful completion of the qualifying year, students advance through a sequence of studies providing for development of building design skills and knowledge of building systems and the technical processes of construction. During the final year of the curriculum, students pursue individual study interests and prepare a thesis. This program usually requires at least three and one half years (three academic years, plus one required summer) of study. Students in the M.Arch.3 program may elect to enroll at the Washington-Alexandria Center for the final, thesis year and/or may spend a semester participating in the Europe Study Abroad Travel Program or in residence at the Center for European Studies and Architecture (CESA) in Riva San Vitale, Switzerland. Accredited degrees: The M.Arch.2 and M.Arch.3 programs are fully accredited by the National Architectural Accrediting Board as first professional degree programs in architecture. In the United States, most state registration boards require a degree from an accredited professional degree program as a prerequisite for licensure. The National Architectural Accrediting Board (NAAB), which is the sole agency authorized to accredit US professional degree programs in architecture, recognizes three types of degrees: the Bachelor of Architecture, the Master of Architecture, and the Doctor of Architecture. A program may be granted a 6-year, 3-year, or 2-year term of accreditation, depending on the extent of its conformance with established educational standards. Masters degree programs may consist of a pre-professional undergraduate degree and a professional graduate degree that, when earned sequentially, constitute an accredited professional education. However, the pre-professional degree is not, by itself, recognized as an accredited degree.

GRADUATE COURSES (ARCH)

ARCH 5035:

Advanced Environmental Controls

Advanced studies of environmental controls, the system, and its physical environmental factors, including development in building systems, urban systems, service systems, construction systems, materials and component systems, psycho-physical consideration, systems analysis, and computer technology. May be repeated for a maximum of 12 credit hours in varied options offered.

Credit Hour(s): 0 OR 3

Lecture Hour(s): 0 OR 2

Instruction Type(s): Lab, Lecture, Online Lecture

Instruction Type(s): Lab, Lecture, Online Lecture

Prerequisite(s): ARCH 4755 (UG), ARCH 4756 (UG)

Corequisite(s):

ARCH 5036:

Advanced Environmental Controls

Advanced studies of environmental controls, the system, and its physical environmental factors, including development in building systems, urban systems, service systems, construction systems, materials and component systems, psycho-physical consideration, systems analysis, and computer technology. May be repeated for a maximum of 12 credit hours in varied options offered.

Credit Hour(s): 0 OR 3

Lecture Hour(s): 0 OR 2

Instruction Type(s): Lab, Lecture, Online Lecture

Instruction Type(s): Lab, Lecture, Online Lecture

Prerequisite(s): ARCH 4755 (UG), ARCH 4756 (UG)

Corequisite(s):

ARCH 5044G:

Professional Practice

Introduction to scope and diversity of the building enterprise, addressing private and public macroeconomic, industrial, technical, professional, and regulatory institutions. Analysis of historic evaluation of professional roles and practices; emergence of new modes of practice, including innovative facilities procurement methods. Pre-requisite: Graduate Standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ARCH 5045:

Environmental Design Research

Methods for identifying, evaluating, and enhancing the knowledge base for design decisions at scales ranging from room to region. Course emphasizes analytic and empirical approaches to characterizing attributes of the physical environments and their transformation into design variables. Sources of emerging knowledge and systems for maintaining technical currency are identified. Bachelors Degree in Environmental Design (B.S. Arch, B. Arch, B.L. Arch) required. Co: UAP 5495 or UAP 5496 or EDAE 5300.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ARCH 5056:

Advanced Building Structures

Study of building forms and structure systems ranging from horizontal-span structures to skyscrapers; preliminary design of masonry buildings, skeletons, tubes, soft and rigid surface structures by considering the complexity of load action that includes wind, seismic, and hidden loads.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ARCH 4775 (UG), ARCH 4776 (UG)

Corequisite(s):

ARCH 5064:

Topics in Computer Applications in Design

Computer system fundamentals. Introduction to programming. Emphasis on computer graphics in 2 and 3-space geometry and graphics-related topics employing several languages. Computer usage in architectural design and production. Exploration of available hard and software through advanced design issues. May be repeated for a maximum of 12 credit hours with different content or topics.

Credit Hour(s): 0 OR 3

Lecture Hour(s): 0 OR 1

Instruction Type(s): Lab, Lecture, Online Lecture

Instruction Type(s): Lab, Lecture, Online Lecture

Prerequisite(s): ARCH 4716 (UG)

Corequisite(s):

Media and the Environment Workshop

The role of various media of visual communication as tools of documentation, analysis, and creation in the designed visual environment. Skills in photography, film, video techniques, and printmaking graphics will be developed in specific relation to environmental design study and presentation.

Credit Hour(s): 0 OR 3

Lecture Hour(s): 0 OR 1

Instruction Type(s): Lab, Lecture, Online Lecture

Instruction Type(s): Lab, Lecture, Online Lecture

Prerequisite(s):

Corequisite(s): ARCH 5715, ARCH 5716, ARCH 5994

ARCH 5116:

Media and the Environment Workshop

The role of various media of visual communication as tools of documentation, analysis, and creation in the designed visual environment. Skills in photography, film, video techniques, and printmaking graphics will be developed in specific relation to environmental design study and presentation.

Credit Hour(s): 0 OR 3

Lecture Hour(s): 0 OR 1

Instruction Type(s): Lab, Lecture, Online Lecture

Instruction Type(s): Lab, Lecture, Online Lecture

Prerequisite(s):

Corequisite(s): ARCH 5715, ARCH 5716, ARCH 5994

ARCH 5125:

Materials Processes Workshop

Characteristics, properties, and uses of various materials and processes as tools of study, analysis, and presentation of the designed environment. The proportion, form, and sectional analysis of hand, wheel, and cast objects are studied. Uses of these materials and the technical process involved are emphasized. Workshop provides framework for design of small scale objects which can relate to environmental design and larger urban scale issues. Co: 5705, 5706 or 5994

Credit Hour(s): 0 OR 3

Lecture Hour(s): 0 OR 1

Instruction Type(s): Lab, Lecture, Online Lecture

Instruction Type(s): Lab, Lecture, Online Lecture

Prerequisite(s):

Corequisite(s): ARCH 5705

ARCH 5126:

Materials Processes Workshop

Characteristics, properties, and uses of various materials and processes

as tools of study, analysis, and presentation of the designed environment. The proportion, form, and sectional analysis of hand, wheel, and cast objects are studied. Uses of these materials and the technical process involved are emphasized. Workshop provides framework for design of small scale objects which can relate to environmental design and larger urban scale issues. Co: 5705, 5706 or 5994.

Credit Hour(s): 0 OR 3

Lecture Hour(s): 0 OR 1

Instruction Type(s): Lab, Lecture, Online Lecture

Instruction Type(s): Lab, Lecture, Online Lecture

Prerequisite(s):

Corequisite(s): ARCH 5706

ARCH 5134:

Topics in Architecture History and Theory

Study and critical evaluation of selected current and historical issues in architecture and environmental design. Materials studied will be in the form of projects and writings of key designers, interpretations by leading critics and analysis by historians. Topics will be selected from such areas as: theories of change in culture and architecture; concepts of expression, image, symbol, and form; problems of functional, rational, and social analysis; perception of space and organization. May be repeated for a maximum of 12 credit hours in varied options offered.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ARCH 4705 (UG)

Corequisite(s):

ARCH 5515:

Arch & Systems Lab

Architecture design laboratory with concentration on development of intellectual and professional skills of analysis, synthesis, and evaluation in design problem solving. Focus on the interrelatedness of the various components of building structure and enclosure, integration of building environmental controls, and the contribution of materials and methods of construction to the design process.

Credit Hour(s): 0 OR 6

Lecture Hour(s): 0 OR 1

Instruction Type(s): Lab, Lecture, Online Lecture

Instruction Type(s): Lab, Lecture, Online Lecture

Prerequisite(s): ARCH 4716 (UG)

Corequisite(s):

ARCH 5516:

Arch & Systems Lab

Architecture design laboratory with concentration on development of intellectual and professional skills of analysis, synthesis, and evaluation in design problem solving. Focus on the interrelatedness of the various components of building structure and enclosure, integration of building environmental controls, and the contribution of materials and methods of construction to the design process.

Credit Hour(s): 0 OR 6

Lecture Hour(s): 0 OR 1

Instruction Type(s): Lab, Lecture, Online Lecture

Instruction Type(s): Lab, Lecture, Online Lecture

Prerequisite(s): ARCH 4716 (UG)

Corequisite(s):

ARCH 5565:

Building Materials and Construction

Building materials, elements, and construction methods, including wood, masonry, concrete, and steel construction, building foundations and sitework, building and zoning codes, building cost considerations, interior finishes, and building envelope systems, including cladding, windows and window walls, curtain walls, roofing, and insulation; emphasis on knowledge of building materials and construction methods in support of architectural design decisions; historical development of building materials and ways of building, standard building practice, and analysis of the construction of significant works of architecture. Graduate standing required.

Credit Hour(s): 0 OR 3

Lecture Hour(s): 0 OR 2

Instruction Type(s): Lab, Lecture, Online Lecture

Instruction Type(s): Lab, Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ARCH 5566:

Building Materials and Construction

Building materials, elements, and construction methods, including wood, masonry, concrete, and steel construction, building foundations and sitework, building and zoning codes, building cost considerations, interior finishes, and building envelope systems, including cladding, windows and window walls, curtain walls, roofing, and insulation emphasis on knowledge of building materials and construction methods in support of architectural design decisions; historical development of building materials and ways of building, standard building practice, and analysis of the construction of significant works of architecture. Graduate standing required.

Credit Hour(s): 0 OR 3

Lecture Hour(s): 0 OR 2

Instruction Type(s): Lab, Lecture, Online Lecture

Instruction Type(s): Lab, Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ARCH 5614:

Theory of Urban Form

Urban forms related to functions; analysis of socioeconomic, political, historical, geographic, and cultural forces influencing urban form.

Concepts of idealized urban forms and theoretical models of urban configuration.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ARCH 4705 (UG)

Corequisite(s):

ARCH 5624:

Urban Design Seminar

Current topics in urban design. Topics may include: theoretical, conceptual and practical concerns in the generation of urban spatial form; the roles of public and private interests in shaping urban form; the effects of urban intensification on the quality of public spaces; environmental issues in urban design; the role of public policy and regulatory mechanisms; the genesis and development of urban typologies. Each seminar will address one of these or related subject areas. Course may be repeated with a different subject for a maximum of 12 credits.

Credit Hour(s): 1 TO 3

Lecture Hour(s): 1 TO 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ARCH 5614 (UG)

Corequisite(s):

ARCH 5644:

Comparative Urbanism Seminar

Explores current issues, situations, and developments in diverse urban settlements across cultures. Direct experience of selected cities will be supported by contemporary and historic readings, maps and drawings to illuminate differential technological, environmental, economic, social and cultural forces shaping subject cities. Research methods applicable to urban design will be discussed. Choice of cities and areas of focus will be determined by students based on their thesis research proposals.

Pre: Graduate standing.

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ARCH 5705:

Architecture and Urbanism Seminar

Review of contemporary concepts in architectural design in the context of the urban environment. Significant architectural works of the twentieth century and the theories of their authors will be studied for an understanding of their contribution to the language of architecture. The attitudes and phenomena which have led to the making of the particular culture of our time will be studied for their impact on the built urban environment.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ARCH 5516 (UG)

Corequisite(s):

ARCH 5706:

Architecture and Urbanism Seminar

Review of contemporary concepts in architectural design in the context of the urban environment. Significant architectural works of the twentieth century and the theories of their authors will be studied for an understanding of their contribution to the language of architecture. The attitudes and phenomena which have led to the making of the particular culture of our time will be studied for their impact on the built urban environment.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ARCH 5516 (UG)

Corequisite(s):

ARCH 5715:

Architecture and Urbanism Laboratory

Advanced design laboratory for identifying needs, resources and operational methodologies across an expanded range of environmental scales. The scope of design includes the relation of the individual building to the environment in comprehensive terms, with particular emphasis on the complexity which exists at the urban scale. Methods for the identification of socio-cultural needs and the coordination of complex variables, information, and resources, leading to the conceptualization

and development of design of the components of the built environment.

Credit Hour(s): 0 OR 6

Lecture Hour(s): 0 OR 1

Instruction Type(s): Lab, Lecture, VB, Online Lecture

Instruction Type(s): Lab, Lecture, VB, Online Lecture

Prerequisite(s):

Corequisite(s):

ARCH 5716:

Architecture and Urbanism Laboratory

Advanced design laboratory for identifying needs, resources and operational methodologies across an expanded range of environmental scales. The scope of design includes the relation of the individual building to the environment in comprehensive terms, with particular emphasis on the complexity which exists at the urban scale. Methods for the identification of socio-cultural needs and the coordination of complex variables, information, and resources, leading to the conceptualization and development of design of the components of the built environment.

Credit Hour(s): 0 OR 6

Lecture Hour(s): 0 OR 1

Instruction Type(s): Lab, Lecture, VB, Online Lecture

Instruction Type(s): Lab, Lecture, VB, Online Lecture

Prerequisite(s):

Corequisite(s):

ARCH 5755:

Advanced Design Laboratory

Complex environmental design problems related to social, cultural, and historical issues examined for contribution to developing appropriate architectural form and aesthetic. Laboratory will focus on research and development of graduate design projects at a range of scales: product, architectural, urban; based on individual interests.

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Lab, VB

Instruction Type(s): Lab, VB

Prerequisite(s): ARCH 4716 (UG)

Corequisite(s):

ARCH 5755G:

Building Environmental Systems

A design oriented study of environmental forces, environmental impacts of the built environment, and related building environmental control, life safety and service systems, with concern for the human psycho-physical impacts of building form and system performance. Prerequisite: Graduate Standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ARCH 4706 (UG)

Corequisite(s):

ARCH 5756:

Advanced Design Laboratory

Complex environmental design problems related to social, cultural, and historical issues examined for contribution to developing appropriate architectural form and aesthetic. Laboratory will focus on research and development of graduate design projects at a range of scales: product, architectural, urban; based on individual interests.

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Lab, VB

Instruction Type(s): Lab, VB

Prerequisite(s): ARCH 4716 (UG)

Corequisite(s):

ARCH 5775G:

Intermediate Bldg Structures

Building structures in steel, timber and reinforced concrete; design of typical components: beams, slabs, columns, beam-columns, connections, and foundations: design of retaining walls; the resistance of buildings to gravity and lateral force action; building stability; floor/roof framing systems; design of simple buildings. Pre-requisite: Graduate Standing required

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ESM 3704 (UG)

Corequisite(s):

ARCH 5776G:

Intermediate Bldg Systems

Building structures in steel, timber and reinforced concrete; design of typical components; beams, slabs, columns, beam-columns, connections, and foundations; design of retaining walls; the resistance of buildings to gravity and lateral force action; building stability; floor/roof framing systems; design of simple buildings. Pre-requisite: Graduate Standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ESM 3704 (UG)

Corequisite(s):

ARCH 5894:

Final Examination

NONE

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ARCH 5904:

Project and Report

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research, Online Research

Instruction Type(s): Research, Online Research

Prerequisite(s):

Corequisite(s):

ARCH 5974:

Independent Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Independent Study, VI, VI1

Instruction Type(s): Independent Study, VI, VI1

Prerequisite(s):

Corequisite(s):

ARCH 5984:

Special Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ARCH 5994:

Research and Thesis

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research, Online Research

Instruction Type(s): Research, Online Research

Prerequisite(s):

Corequisite(s):

ARCH 6005:

Movements in Architecture and Western Thought

Platform for advanced studies in the historic and canonic evidence of the objective reality of architecture. Establishes a basis on which an emerging designer can build for future work and inquiry. Pre-requisite:

Graduate Standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ARCH 6006:

Movements in Architecture and Western Thought

Platform for advanced studies in the historic and canonic evidence of the objective reality of architecture. Establishes a basic on which an emerging designer can build for future work and inquiry. Pre-requisite:

Graduate Standing required

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ARCH 6984:

Special Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ARCH 7994:

Research and Dissertation

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research, Online Research

Instruction Type(s): Research, Online Research

Prerequisite(s):

Corequisite(s):

ARCHITECTURE AND DESIGN RESEARCH

Aaron Betsky, Program Director

Emeriti Faculty: Patrick Miller; Humberto Rodriguez-Camilloni;

Professors: Markus Breitschmid; Paul Emmons; James Jones; Mehdi Setareh;

Associate Professors: Dean Bork; Hilary Bryon; Terry Clements; Marcia

Feuerstein; Brian Katen; Paul Kelsch; Mintai Kim; Lisa Tucker;

Assistant Professors: Elizabeth Grant;

Affiliated Faculty: David Lever;

Graduate Coordinator: vaughnw@vt.edu

Graduate Chair: ddugas@vt.edu

Blacksburg Program: wolverine@vt.edu

Alexandria Program: pemmons@vt.edu

Landscape Architecture Track: mintkim@vt.edu

Interior Design: ltucker@vt.edu

School of Architecture + Design: <http://archdesign.vt.edu/architecture/>

Washington Alexandria Architecture Center: <http://www.waac.vt.edu/>

Ph.D. in Architecture and Design Research

<http://archdesign.vt.edu/architecture-design/phdDegree> Tracks within the

Ph.D. in Architecture and Design Research There are two major tracks within the Architecture and Design Research degree, each of which has topical areas. The requirements for the tracks vary slightly, but both provide significant flexibility for each student to develop a plan of study consistent with his or her academic goals. The two tracks are Architecture and Design Research. Architecture Track The Architecture track includes Architectural Representation and Education, Architectural History and Theory, Historic Preservation, and Computing and Representation. The Architecture track will share resources on the Blacksburg Campus and the Washington Alexandria Architecture Center in the National Capital Region. At the latter location, students have the best resources to develop their topics in architectural representation, since they can make use of the many research libraries available in the Washington, DC area, including the Library of Congress, National Building Museum library, American Institute of Architects Library, CASVA, Smithsonian Institution, the Dumbarton Oaks Library and many privately owned architectural archives. Design Research Track The Design Research track includes advanced study on Building Science, Industrial Design, Interior Design, and Landscape Architecture. The Landscape Architecture Track includes concentrations in: Design Learning and Professional Paradigms; Regenerative/Ecological Design, Planning and Technology; and Concepts of Community and Place. The Design Research track is currently located in Blacksburg, VA at the Virginia Tech Main Campus. In this location students have the best resources to develop their topics in design research given that the

faculty of the School of Architecture Design have established collaborative relationships with other university centers and institutions. Admission The faculty are seeking to admit a highly selective group of students who have master's degrees in closely allied fields, such as Architecture, Environmental Design, Building Science, Landscape Architecture, Architecture History and Theory, Interior Design, and Industrial Design. In addition to the application requirements of the Virginia Tech Graduate School and those pertaining to all graduate programs within the School of Architecture Design, applicants to the PhD degree in Architecture and Design Research must submit a portfolio and a 2,500 word statement of research focus.

SPECIAL FACILITIES

Washington - Alexandria Architecture Center in the Virginia Tech National Capital Region (Architecture track) Cowgill Hall, Virginia Tech Blacksburg Campus (Design Research track in Building Science and Industrial Design) Burruss Hall, Virginia Tech Blacksburg Campus (Design Research track Landscape Architecture and Interior Design)

School of Architecture + Design Facilities

Cowgill Hall Art & Architecture Library Burchard Hall Burruss Hall Collegiate Square Studio Research + Demonstration Facility Advanced Design and Construction Facility Washington - Alexandria Architecture Center National Capital Region (NCR) Center for European Studies and Architecture

DEGREES OFFERED

PhD Degree

Offered In (Blacksburg, National Capital Region)

TOEFL

Paper: (600.0)

Computer: (250.0)

iBT: (100.0)

Ph.D. in Architecture and Design Research: * The Graduate School requires each Ph.D. student to complete 90 semester hours of graduate study and dissertation. * All students, regardless of area of specialization, are required to complete a sequence of specific Architecture and Design Seminars. A two-semester sequence seminar will focus primarily on epistemology and the nature of discipline and practice of architecture, viewed in the context of architecture and the allied fields. Students will also enroll in a continuing seminar course required every semester of residence. In these seminars, Ph.D. students, the School faculty involved with the graduate program, and possible guests present their own research for critical review and feedback. The Ph.D. students in the Architecture track must also pass a test of reading ability in a foreign language related to their selected topics (native languages and English do not fulfill this requirement). Students who are undertaking Ph.D. studies in landscape architecture should include the following courses in their program of study: ARCH 5045 - Design Research Methodology LAR 5724 - Scholarship in Landscape Architecture EDRE 6605 - Quantitative Research Methods in Education I (or equivalent approved by student's committee). EDRE 6504: Qualitative Methods in Educational Research I (or equivalent approved by student's graduate committee). * In addition, all students

must complete a special Research Methods course organized by area of specialization. At the approval of the student's advisory committee the course may be also taken in the other area of specialization or outside of the school.

BUILDING/CONSTRUCTION SCIENCE AND MANAGEMENT

Georg Reichard, Head

Professors: Yvan Beliveau; Brian Kleiner; Andrew McCoy; Georg Reichard; Walid Thabet;

Associate Professors: Thomas Mills; Annie Pearce; Muhsine Turkaslan Bulbul;

Assistant Professors: Kereshmeh Afsari; Philip Agee; Abiola Akanmu; Xinghua Gao; Nazila Roofigari-Esfahan;

Assistant Professor of Practice: Aleksandra Markovic Graff;

Associate Professor of Practice: Josh Iorio;

Graduate Contact: reichard@vt.edu

General Contact: iorio@vt.edu

Building Construction: <http://www.bc.vt.edu/graduate-programs>

At the Master's level, the Building Construction curriculum prepares students with the professional capabilities to critically address present and evolving needs of the construction industry. The Master of Science in Building Construction Science and Management (MS-BCSM) degree offers the opportunity for advanced study and research in specialized areas related to building design, construction, operations, and end-of-life-cycle, providing the basis for diverse career paths in the construction industry or entry into a Ph.D. level program. While an undergraduate degree in Building Construction or related fields is not required, applicants must demonstrate relevant background, and professional experience in the construction industry is recommended. Applicants must also demonstrate the capability for undertaking advanced academic study. The Master of Science degree in BCSM requires a total of 32 credit hours of core courses and electives. Students may complete their degree requirements through independent investigation on a subject of their own interest through a faculty-supervised Thesis or Project & Report, or they may elect to complete their degree requirements through a final exit examination.

SPECIAL FACILITIES

Bishop-Favrao Hall (BFH) is a 31,600 square foot laboratory facility opened in 2008. It is the home of the Myers-Lawson School of Construction and the Department of Building Construction. BFH was designed to be used as a teaching tool. The structural elements that are usually hidden behind walls and ceiling panels in other buildings are exposed and labeled. That means students can clearly see the structures and systems they are studying in use. All public spaces and all offices have exposed ceilings to allow students and visitors to see the structural, mechanical, electrical, plumbing, fire protection, and electrical systems. The building was specifically designed with large open work spaces, conference and meeting rooms in order to foster a collaborative atmosphere, and flexible spaces available in this building range from two 100-person classrooms to 10-person conference rooms and

reconfigurable studio spaces. The building is also home to multiple research labs and centers dedicated to inventing the future of the human-centered built environment. In addition to state-of-the-art research facilities, the building contains administrative, faculty, and graduate student offices. Bishop-Favrao Hall was made possible by numerous Building Construction alumni and friends, many of whom are noted on the donor wall located in the second floor lobby and on plaques around the building. The building is named after Richard Bishop and William A. Favrao. Address: 1345 Perry St. | Map Grid: K-3 Originally Built: 2007 | Abbreviation: BFH

ARCaDe Lab

The Automation & Robotics in Construction And Design (ARCaDe) Lab mission is to advance research and development in the next generation built environment technologies leveraging innovative solutions for design, construction, and operations of buildings and infrastructures. The ARCaDe Lab at Virginia Tech is involved in collaborative interdisciplinary research between the College of Architecture and Urban Studies and the College of Engineering to develop new solutions for the Architecture, Engineering, Construction, and Operations (AECO) industry. The ARCaDe Lab is focused on: Applied research through collaboration with industry Scientific investigations Educational excellence Technology leadership Key areas include: Automated and integrated solutions to optimize building design, construction, and operations Robotic technology and control system for improved productivity and safety Smart sustainable buildings and infrastructure with innovations in cyber-physical systems Adaptive human-centered environments to improve human comfort, safety, and wellbeing AECO education through innovations in the integration of emerging technologies

BEST Lab

The Building Enclosure and Systems Technologies (BEST) Lab was founded in 2008 for the study of environmental building systems and enclosure systems and their interrelated thermal, hygrothermal, and acoustic performance, as well as performance aspects of mechanical, electrical, and lighting systems. This lab contains a full-scale building assembly test chamber as well as a variety of portable equipment for monitoring and measuring building conditions, including lighting, indoor air quality, as well as interior and exterior environmental conditions.

BuildLAB

The BuildLAB is a 6,000 square foot fabrication facility equipped for digital design and construction, this lab focuses primarily on wood and composite materials. The lab includes a full spectrum of portable and fixed conventional construction equipment, computer controlled additive and subtractive manufacturing tools, and a trailer-mounted field office and tool storage unit that can be used for projects off-site.

IC-SAFE

The Center for Innovation in Construction Safety, Health, and Well-being (IC-SAFE) is a university center that provides national leadership for construction safety, health, and well-being through research,

teaching, and engagement. The Center works with laboratories throughout campus to facilitate research to promote the health, safety, and well-being of construction workers and others involved in the building life cycle.

SFI Lab

The Sustainable Facilities & Infrastructure (SFI) Lab is a distributed lab that focuses on the study of sustainable technologies and systems in the built environment and the human systems with which they interact. The lab's equipment includes renewable energy feasibility assessment equipment, a portable audience-interactive charrette facilitator's kit, and a building condition assessment toolkit used to evaluate building performance and conditions in the field.

VCHR

The Virginia Center for Housing Research (VCHR) -the official housing research center for the Commonwealth of Virginia, VCHR provides housing-related data services and analysis to local government, the Commonwealth, and other organizations.

VFRL

The Virtual Facilities Research Lab includes a 250 square foot visualization space as well as other spaces throughout Bishop-Favrao Hall. With a focus on Building Information Modeling (BIM), the lab explores challenges related to interoperability, design for safety, asset and facility management, and simulation.

DEGREES OFFERED

MS Degree

Offered In (Blacksburg)

GRE

Prior to 2010: Minimum (1000.0)

After 2010: Minimum (verbal+quantitative) (305.0)

TOEFL

Paper: (620.0)

iBT: (105.0)

IELTS

Overall: Total (7.5)

The Master of Science in Building Construction Science and Management program consists of 32 credit hours of coursework including core courses and electives in construction-, design-, and business-related disciplines. Students may complete their degree requirements either through independent investigation on a subject of their own interest through a faculty-supervised Thesis or Project & Report, or through a final exit examination administered by the faculty. GRE Requirements: GRE scores are required from all applicants. TOEFL Requirements: TOEFL scores are required of all international applicants who have not matriculated from an English-speaking university, due to the language-intensive nature of the program. Application Deadlines: All required documents must be received in the Graduate School by the Department's application deadline in order for the application to be complete. The Master of Science in Building

Construction Science & Management (MS-BCSM) program accepts applications for fall terms only. (Active duty Military applicants can request a spring start.) The Department conducts general admission reviews and decisions within a month following the application deadline. Early reviews and admission decisions can be requested based on faculty recommendations. The deadlines below are the latest possible dates that an application will be considered. Funded Students: Students wishing to be considered for assistantship funding should apply no later than April 1st for Fall admission. International Students : Application Deadline for M.S. applicants is April 1st. Most department decisions will be made by April 15th. Domestic Students : Application Deadline for M.S. applicants is July 1st. Decisions are anticipated to be made by July 15th.

Degree Concentrations:

Industry Track

The Industry Track offers opportunities for students who are interested in a career in the Architecture, Engineering, and Construction (AEC) industry after graduation. This track allows students to explore the key topics and issues that face the AEC industry, working closely with faculty and industry leaders. Students in this track may customize their course of study through their choice of elective courses both inside and outside the School of Construction, as well as through independent study working directly with faculty. Internships, executive shadowing experiences, and extracurricular opportunities round out the industry track experience, resulting in students who will be well-prepared to develop cutting edge solutions to industry challenges and carry their companies forward into the future. Students will complete their degree in this track with a final oral exit exam administered by construction faculty.

Research Track

The Research Track offers a chance for students who wish to explore an industry problem at a deeper level, or who are considering further study at the doctoral level as part of their future career goals. This track offers both the basic coursework to equip graduates for a construction career as well as a chance to focus in detail on a problem of interest through a faculty-supervised one-semester project or two-semester thesis. Students in this track may customize their course of study using electives both inside and outside the Myers-Lawson School of Construction and will choose three faculty with complementary expertise to supervise their research in a problem area of interest to them. Students in this track have the opportunity to interact with industry through internships as well as working directly with companies to complete their research investigations. Graduates of this track will be equipped to pursue fast-track careers in industry or in academia through further study.

GRADUATE COURSES (BC)

BC 5024:

Cost Management of the Building Process

A study of cost management procedures applicable to the building process from concept through owner operations. Cost considerations in the decision process, concepts for monitoring and controlling costs, and the determination of accountability are examined. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

BC 5064:

Innovation in Construction

An introduction to the role of innovation in the construction industry, including the explanation of theories within the realm of innovation, diffusion, adoption, new product development, supply chain management, sustainability, information technology and commercialization. The course emphasizes application of these theories to construction industry innovation through the development and administration of a survey instrument and interviews that culminating in a case study of best practice for innovation development. Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

BC 5114G:

Advanced Building Information Modeling In Design and Construction

Introduction to means and methods to enrich the geometric information of a building model with semantic data such as material, structural and performance values. Concept of interoperability in architecture, engineering and construction industry. Overview of approaches to information modeling such as Standard for the Exchange of Product model data (STEP), Industry Foundation Classes (ifc), Construction Operations Building Information Exchange (COBie), and Green Building XML (gbXML). Key concepts of object-oriented modeling and programming. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

BC 5124G:

Advanced Digital Construction & Manufacturing

Explore and experiment with construction from the perspective of digital information, computer numerical control (CNC), and computer aided manufacturing (CAM) processes. Tools like 3D scanners, 3D printers, CNC manufacturing techniques, and others will be used in a lab setting intended to provide familiarity with these technologies and a sense of their benefits and limitations. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 2

Instruction Type(s): Lab, Lecture, VB, Online Lecture

Instruction Type(s): Lab, Lecture, VB, Online Lecture

Prerequisite(s):

Corequisite(s):

BC 5134:

Sustainable Facility Systems

Introduction to means, methods, and analytical practices associated with sustainability in the built environment. Best practices for sustainable projects in the areas of planning/development, site design, project management, energy and water conservation and efficiency, green building materials, and indoor environmental quality. Analytical methods include green building assessment tools and methods; Leadership in Energy and Environmental Design (LEED) rating system; economic analysis of green building alternatives; and evaluation for innovation and organizational change. Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

BC 5144:

Sustainable Infrastructure Systems

Relevant issues and state of the art technologies for sustainable civil infrastructure systems, including energy generation, water supply and treatment, wastewater systems, solid waste systems, and transportation/mobility systems. Analytical methods include development-scale sustainability assessment tools and methods; green materials performance assessment and evaluation; economic analysis of system alternatives; demand assessment/optimization; and conceptual design approaches for different system types. Graduate standing required.

Credit Hour(s): 0 OR 3

Lecture Hour(s): 0 OR 2

Instruction Type(s): Lab, Lecture, Online Lecture

Instruction Type(s): Lab, Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

BC 5154:

Modeling in Design and Construction

Concepts, theory, and practice of building information modeling during design and construction. Building delivery and project management concepts in relation to building information modeling. Computer applications for visualization, modeling, simulation, scheduling, and estimating. Analyze models for critical analysis and problem solving in the design, planning, and management of a construction project. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 2

Instruction Type(s): Lab, Lecture, VB, Online Lecture

Instruction Type(s): Lab, Lecture, VB, Online Lecture

Prerequisite(s):

Corequisite(s):

BC 5264G:

Advanced Fundamentals of Construction Management

Practical construction methods within the built environment. Construction materials, document drawings, management activities, fundamentals of construction scheduling and planning. Quality, quantity, and cost of materials necessary to complete a construction project. Construction information technology tools. Pre: Graduate Standing.

Credit Hour(s): 6

Lecture Hour(s): 6

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

BC 5314:

Applied Building Sciences

Fundamentals of building physics and other sciences dealing with the built environment, scientific means and methods for evaluating and simulating building performance in various contexts, emphasis is put on thermal, hygrothermal (moisture and mold), lighting, daylighting, acoustic performance - all performance topics are evaluated over the life cycle of a building and their impact on sustainability. Graduate standing required.

Credit Hour(s): 3

459 Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

BC 5374:

Advanced Lifecycle BIM for Facility Management

BIM (Building Information Modeling) concepts and tools for identifying, capturing, analyzing, and delivering facility life cycle data. Data-centric and model-centric workflows for data handover. BIM models for a system-oriented model review and case study utilization. Advanced tools and programming language to search the BIM model. Workflow process. Apply case studies to assess MEP (Mechanical, Electrical, Plumbing) systems from a facility manager perspective. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

BC 5514:

Principles and Practices of Construction I

Using a case study approach coupled with several term projects to achieve its objectives, this course covers the principles and practices of construction means and methods for CSI divisions 1-6 with emphasis on concrete, masonry, and steel construction. The course also integrates topics in project management, including project contract types and delivery methods, bonds and insurance, conceptual and detailed cost estimating methods, planning and scheduling techniques, and resource/cost scheduling. Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

BC 5524:

Principles and Practices of Construction II

Using a case study approach with various term projects, this course builds on concepts covered in BC 5514, focusing on the principles and practices of construction means and methods for CSI divisions 7-13. Emphasis is given to finishing works, thermal and moisture protection procedures, curtain wall construction, and special construction methods. The course integrates advanced topics in project management including schedule updating techniques, resource and cost tracking and control

tools, and linear scheduling.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): BC 5514 OR BC 55514 (UG)

Corequisite(s):

BC 5904:

Project and Report

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research

Instruction Type(s): Research

Prerequisite(s):

Corequisite(s):

BC 5974:

Independent Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Independent Study

Instruction Type(s): Independent Study

Prerequisite(s):

Corequisite(s):

BC 5984:

Special Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

BC 5994:

Research and Thesis

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research

Instruction Type(s): Research

Prerequisite(s):

460 Corequisite(s):

BC 6984:

Special Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ENVIRONMENTAL DESIGN AND PLANNING

Georg Reichard, Head

Professors: Yvan Beliveau; Brian Kleiner; Andrew McCoy; Georg Reichard; Walid Thabet;

Associate Professors: Thomas Mills; Annie Pearce; Muhsine Turkaslan Bulbul;

Assistant Professors: Kereshmeh Afsari; Philip Agee; Abiola Akanmu; Xinghua Gao; Nazila Roofigari-Esfahan;

Associate Professor of Practice: Josh Iorio;

Graduate Contact: reichard@vt.edu

General Contact: iorio@vt.edu

Graduate Site: <http://www.bc.vt.edu/graduate-programs>

The Environmental Design and Planning (EDP) program at Virginia Tech prepares doctoral students with the professional and academic skills to address the challenges of creating and maintaining tomorrow's built environment. The Doctor of Philosophy degree offers the opportunity for advanced study and research in specialized areas relating to building design, construction, and operations, providing the basis to contribute to the field from positions in either industry or academia. Applicants must demonstrate the capability to undertake advanced academic studies including independent research. While a prior degree in construction and industry experience are not required for admission, applicants must demonstrate relevant background and capabilities to succeed at the advanced study level. A minimum of 90 credit hours is required with a minimum of 27 hours of core coursework.

SPECIAL FACILITIES

Bishop-Favrao Hall (BFH) is a 31,600 square foot laboratory facility opened in 2008. It is the home of the Myers-Lawson School of Construction and the Department of Building Construction. BFH was designed to be used as a teaching tool. The structural elements that are usually hidden behind walls and ceiling panels in other buildings are exposed and labeled. That means students can clearly see the structures and systems they are studying in use. All public spaces and all offices have exposed ceilings to allow students and visitors to see the structural, mechanical, electrical, plumbing, fire protection, and electrical systems. The building was specifically designed with large open work spaces, conference and meeting rooms in order to foster a collaborative

atmosphere, and flexible spaces available in this building range from two 100-person classrooms to 10-person conference rooms and reconfigurable studio spaces. The building is also home to multiple research labs and centers dedicated to inventing the future of the human-centered built environment. In addition to state-of-the-art research facilities, the building contains administrative, faculty, and graduate student offices. Bishop-Favrao Hall was made possible by numerous Building Construction alumni and friends, many of whom are noted on the donor wall located in the second floor lobby and on plaques around the building. The building is named after Richard Bishop and William A. Favrao. Address: 1345 Perry St. | Map Grid: K-3 Originally Built: 2007 | Abbreviation: BFH

ARCaDe Lab

The Automation & Robotics in Construction And Design (ARCaDe) Lab mission is to advance research and development in the next generation built environment technologies leveraging innovative solutions for design, construction, and operations of buildings and infrastructures. The ARCaDe Lab at Virginia Tech is involved in collaborative interdisciplinary research between the College of Architecture and Urban Studies and the College of Engineering to develop new solutions for the Architecture, Engineering, Construction, and Operations (AECO) industry. The ARCaDe Lab is focused on: Applied research through collaboration with industry Scientific investigations Educational excellence Technology leadership Key areas include: Automated and integrated solutions to optimize building design, construction, and operations Robotic technology and control system for improved productivity and safety Smart sustainable buildings and infrastructure with innovations in cyber-physical systems Adaptive human-centered environments to improve human comfort, safety, and wellbeing AECO education through innovations in the integration of emerging technologies

BEST Lab

The Building Enclosure and Systems Technologies (BEST) Lab was founded in 2008 for the study of building enclosure systems and their interrelated thermal, hygro-thermal, and acoustic performance, as well as performance aspects of mechanical, electrical, and lighting systems. This lab contains a full-scale building assembly test chamber as well as a variety of portable equipment for monitoring and measuring building conditions, including lighting, indoor air quality, as well as interior and exterior environmental conditions.

BuildLAB

The BuildLAB is a 6,000 square foot fabrication facility equipped for digital design and construction, this lab focuses primarily on wood and composite materials. The lab includes a full spectrum of portable and fixed conventional construction equipment, computer controlled additive and subtractive manufacturing tools, and a trailer-mounted field office and tool storage unit that can be used for projects off-site.

IC-SAFE

The Center for Innovation in Construction Safety, Health, and Well-being (IC-SAFE) is a university center that provides national leadership

for construction safety, health, and well-being through research, teaching, and engagement. The Center works with laboratories throughout campus to facilitate research to promote the health, safety, and well-being of construction workers and others involved in the building life cycle.

SFI Lab

The Sustainable Facilities & Infrastructure (SFI) Lab is a distributed lab that focuses on the study of sustainable technologies and systems in the built environment and the human systems with which they interact. The lab's equipment includes renewable energy feasibility assessment equipment, a portable audience-interactive charrette facilitator's kit, and a building condition assessment toolkit used to evaluate building performance and conditions in the field.

VCHR

The Virginia Center for Housing Research (VCHR) -the official housing research center for the Commonwealth of Virginia, VCHR provides housing-related data services and analysis to local government, the Commonwealth, and other organizations.

VFRL

The Virtual Facilities Research Lab includes a 250 square foot visualization space as well as other spaces throughout Bishop-Favro Hall. With a focus on Building Information Modeling (BIM), the lab explores challenges related to interoperability, design for safety, asset and facility management, and simulation.

DEGREES OFFERED

PhD Degree

Offered In (Blacksburg)

GRE

Prior to 2010: Minimum (1000.0)

After 2010: Minimum (verbal+quantitative) (305.0)

TOEFL

Paper: (620.0)

iBT: (105.0)

IELTS

Overall: Total (7.5)

The Environmental Design and Planning (EDP) program at the College of Architecture and Urban Studies at Virginia Tech prepares doctoral students with the professional and academic skills to address the challenges of creating and maintaining tomorrow's built environment. The Doctor of Philosophy degree offers the opportunity for advanced study and research in specialized areas relating to building design, construction, and operations, providing the basis to contribute to the field from positions in either industry or academia. The Ph.D. in Environmental Design and Planning is a STEM-designated degree. All applicants to the EDP Program must demonstrate the capability to undertake advanced academic study including independent research. While a prior degree in construction-related fields or construction industry experience is not required for admittance, applicants must

demonstrate relevant background and capabilities to succeed at the advanced study level. A minimum of 90 credit hours is required with a minimum of 27 hours of coursework. Students must also successfully complete the Qualifying and Preliminary Exams, Proposal Defense, and Dissertation Defense to meet all degree requirements. GRE Requirements : GRE scores are required for all applicants. TOEFL Requirements : TOEFL scores are required of all international applicants who have not matriculated from an English-speaking university. A minimum score of 105 of the iBT is required for this language-intensive program. Application Deadlines : All required documents must be received in the Graduate School by the application deadline in order for the application to be complete. The Environmental Design & Planning program primarily expects applications for the fall terms. Students interested in beginning the Ph.D. program during other terms should contact the Department of Building Construction for additional information. The Department typically conducts admission reviews and makes decisions within one month after the application deadline. Early reviews and admission decisions can be requested based on faculty recommendations. The deadlines below are the latest possible dates that an application will be considered for fall admission. Students wishing to be considered for funding should directly contact faculty as soon as possible with whom they are interested to work to discuss their interests and funding needs. Funded Students: Students wishing to be considered for funding must apply no later than April 1st for Fall admission International Students : Application Deadline for Ph.D. applicants is April 1st for fall admission. Most department decisions will be made by April 15th. Domestic Students : Application Deadline for Ph.D. applicants is July 1st for fall admission. Decisions are anticipated to be made by July 15th.

GRADUATE COURSES (EDP)

EDP 5184:

Fundamentals of Practice-based Research Methods

Introduction to practice-based research methods and strategies for Environmental Design and Planning disciplines, and their contributions to disciplinary knowledge. Ethics and academic integrity in practice-based research. Tools and methods for framing, mapping, analyzing and evaluating a practice. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

EDP 5284:

Advanced Practice-Based Research Methods

Advanced strategies and techniques for practice-based research in Environmental Design and Planning disciplines. Methods to situate research in communities of practice. Appraisal of external influences on practice-based research. Techniques to differentiate practices based on material, operations and methodologies.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): EDP 5184

Corequisite(s):

EDP 5974:

Independent Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Independent Study

Instruction Type(s): Independent Study

Prerequisite(s):

Corequisite(s):

EDP 5984:

Special Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

EDP 6005:

Seminar in Environmental Design & Planning

Historical context for, and nature of, research in fields encompassed by environmental design and planning; theoretical underpinnings and methodological approaches; current research directions; and selected case studies of research projects.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

EDP 6006 (SPIA 6006):

Seminar in Environmental Design & Planning

Historical context for, and nature of, research in fields encompassed by environmental design and planning; theoretical underpinnings and methodological approaches; current research directions; and selected case studies of research projects.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

EDP 6984:

Special Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

EDP 7994:

Research and Dissertation

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research

Instruction Type(s): Research

Prerequisite(s):

Corequisite(s):

LANDSCAPE ARCHITECTURE

Terry Clements, Chair

Emeriti Faculty: Dean Bork; Benjamin Johnson; Patrick Miller;

Professors: Terry Clements;

Associate Professors: Cermetrius Bohannon; Nathan Heavers; Wendy Jacobson; Brian Katen; Paul Kelsch; Mintai Kim;

Graduate Program Director: mintkim@vt.edu

LAR Program Administrator: slough@vt.edu

LAR Program Chair: tclement@vt.edu

Landscape Architecture Program: <https://archdesign.caus.vt.edu/lar/>

Ph.D. in Architecture and Design Research - Landscape Architecture track:
<https://archdesign.caus.vt.edu/degrees/ph-d-in-architecture-and-design-research-lar/>

Master of Landscape Architecture: <https://archdesign.caus.vt.edu/lar/degrees/>

Master of Landscape Architecture, Adv. Placement:

<https://archdesign.caus.vt.edu/lar/degrees/>

The Landscape Architecture Program in the School of Architecture + Design has an established international reputation as one of North America's leading and highly-ranked programs. The program offers three tracks to a Master of Landscape Architecture (MLA) degree: a 3-year first-professional track, an advanced placement track, and a one year plus thesis track. PhD studies focused in landscape architecture are offered through the Architecture Design Research PhD in the School of Architecture + Design. Non-degree students from other universities are invited to study with us for one or two semesters. Degree applicants with undergraduate qualifications in any discipline are considered for the three-year Master of Landscape Architecture track. The first-professional degree's studio-based curriculum integrates design and planning, landscape sciences and technologies, ecology, and human/environment interaction. Applicants with a previous degree in landscape architecture, architecture or an allied area may be admitted with advanced standing to the two-year MLA track, an option that encourages students to develop an individualized program of study building upon the program's areas of expertise in community engagement, place-making, ecological design and resiliency, and design learning. Our MLA students and graduates routinely find work in design and planning firms, government and municipal agencies, and community and non-profit organizations across the United States and abroad. The three tracks to a Masters in Landscape Architecture are rigorous and intensive studies integrating students' creativity, new and developing knowledge, and problem-solving skills as they address contemporary design and planning challenges in the built environment. The Landscape Architecture Program guides students as they address some of the most important challenges of our time: climate change; healthy living and empathetic design; urbanization; re-imagining water, food, energy and transportation systems; green infrastructure; remediation of spoiled and disturbed sites; and preserving critical natural and cultural resources.

SPECIAL FACILITIES

Graduate students have permanent work stations in the open Landscape Architecture Studio. The studio is shared with other master of landscape architecture students, as well as upper year undergraduate students. As part of the School of Architecture + Design, students have access to wood, ceramic, metal and print-making shops, as well as other maker-spaces.

Community Design Assistance Center

The Community Design Assistance Center assists communities, neighborhood groups, and non-profit organizations in improving the natural and built environments through design, planning, policy and research.

Landscape Architecture Studio and Program Spaces

The landscape architecture design studios feature an open plan allowing students in different courses to be part of a larger cohort of learners. The studios are located in the Surge Building. Faculty offices and seminar spaces are located in Burruss Hall, along with PhD student spaces. The program has full access to all of the School of Architecture + Design facilities and equipment including wood and metal shops and print-making studios in Burchard Hall; ceramic studios in Cowgill and Burchard Halls; computer labs, photographic lab and darkrooms in Cowgill Hall.

DEGREES OFFERED

MLA Degree

Offered In (Blacksburg)

TOEFL

Paper: (600.0)

Computer: (250.0)

iBT: (100.0)

The Landscape Architecture Program offers three tracks for pursuing a Master of Landscape Architecture degree (MLA), depending on the student's academic and professional experience. All students completing a MLA program at Virginia Tech will have met the Landscape Architecture Accreditation Board's (LAAB) requirements of a professional degree program. The tracks include: the three-year first-professional Master of Landscape Architecture track, the advanced placement Master of Landscape Architecture track, for those with an undergraduate degree in landscape architecture or a closely allied field, and the one-year plus thesis Master of Landscape Architecture track for those with significant professional experience. A PhD focused on landscape architecture is offered through the School of Architecture + Design's PhD in Architecture and Design Research. The three-year first-professional Master of Landscape Architecture track is designed for individuals who have completed a bachelor's degree in a field other than landscape architecture. The program offers a studio-based curriculum integrating three focal areas central to practice of landscape architecture into the future: people and place, community engagement, and design for resilience. Emphasis is given to developing mastery of landscape architectural design through a series of design studios and a final thesis project that investigate challenges to the built environment across a range of scales from sites to regions. Individuals are admitted on a competitive basis. Applicants, who have completed a baccalaureate degree or its equivalent, are eligible for admission. Applications are reviewed by a faculty committee and evaluated on the basis of previous academic performance, relevant experience, statement of interest, and evidence of potential to successfully pursue graduate-level work in landscape architecture. Our students have varied educational backgrounds and experience. College-level courses in the natural sciences, ecology, urban and regional planning, and the visual arts (e.g., drawing, sculpture, printmaking, and/or basic design) are recommended although not required. Applicants with previous education in design, an undergraduate degree in architecture or another closely related field, or who have substantial equivalent coursework in landscape architecture, environmental design or landscape design may be eligible for admission with advanced standing, subject to the review of the admissions committee. A transcript, coursework and portfolio review will be conducted for applicants seeking advanced standing. Interested persons are encouraged to contact the program. Admitted degree candidates will be recommended for the Master of Landscape Architecture professional degree upon satisfactory completion of 75 credit hours (typically 25 credits hours of Foundation Studies plus 50 credit hours of MLA Studies) including a design thesis. Foundation Studies prepare students to perform at the graduate level and include introductory course work in history, theory, design, technique, and natural systems. Some coursework may be waived for previous experience or content covered in undergraduate studies. MLA studies include a sequence of required studios, core coursework, and directed electives. Directed electives support the development of a student's desired area of mastery, and may be taken from various areas of study offered across the university. Graduate Studies culminate with a design thesis directed by a major

professor. See: 3-year First-professional MLA track. The advanced placement MLA track is tailored for students who already hold an accredited first professional-degree in landscape architecture, architecture or another closely related field. Students may receive up to a year of advanced standing. This MLA degree track is dedicated to the advancement of knowledge and to advancing an understanding of landscape architecture within four areas: community engaged design, design for resiliency, people and place, and design learning and education. Applicants are asked to specify their area of research interest upon application. Each student in the advanced MLA program works in consultation with a major professor to craft an individualized graduate plan of study within a specific area of focused research. The plan of study includes both general landscape architecture courses and coursework pertaining to an area of research focus. The graduate plan of study typically includes at least 50 credit hours. Nine of these hours are devoted to a capstone thesis that addresses a specific issue or question within the student's selected area of focused research. Students from a related field must also complete additional coursework necessary to fulfill any remaining requirements for a professional MLA degree. A transcript, coursework and portfolio review will be conducted to identify necessary coursework. See: Advanced Placement track Masters of Landscape Architecture The 1 Year Plus Thesis MLA is an accelerated degree designed for students who have both a professional degree in landscape architecture or a closely related field and considerable practical experience. The program is designed to allow seasoned practitioners an opportunity to earn an advanced degree by completing focused studies in an individually tailored program. See: 1year + thesis Masters of Landscape Architecture Track. Dual Degree Programs: MLA students may pursue a simultaneous master degree in Urban and Regional Planning (MLA/MURP). The dual degree programs coordinate course requirements in both fields, assuring the integrity of each while also saving time and cost to the student. Dual degree students must be admitted to both programs following the admissions procedures in each. Students may apply for admission to both programs before enrolling in either, or they may apply after first being admitted to and enrolling in one program. In the latter case, application to the second program should be made before half the coursework in the first has been completed. The MLA/MURP Dual Degree Program recognizes the fundamental linkage between planning and design of the natural environment as impacted by humans. This program shares electives and/or the substitution of significantly relevant courses from each field. Individualized plans of study for students seeking simultaneous degrees are based upon student backgrounds and needs. A capstone product is required of each program. The capstone product may bridge the fields of each degree. Off Campus Studies: MLA students may elect to participate in the Landscape Architecture Program's Summer Education Abroad Program or in university exchange programs offering landscape architecture coursework. Off-campus coursework will be reflected in the student's individual Program of Study and must receive prior approval from their major professor.

PhD Degree

Offered In (Blacksburg)

TOEFL

Paper: (600.0)

Computer: (250.0)

iBT: (100.0)

Ph.D. in Architecture and Design Research offered at Blacksburg and National Capital Region (NCR) Campus: Students may pursue Ph.D.

level studies in landscape architecture through the School of Architecture + Design's "Design Research" track of the Ph.D. program in Architecture and Design Research. Ph.D. candidates pursue an individual course of study and independent research related to an aspect of landscape architecture. The program supports candidates interested in entering academic and professional practices around the world.

GRADUATE COURSES (LAR)

LAR 5005:

Graduate Landscape Architecture Design Laboratory

Graduate landscape architecture laboratory addressing complex issues of landscape design and planning. The scope of planning and design includes the relationship of specific sites to their larger urban and/or regional contexts. Pre: undergraduate degree in landscape architecture or related field, or permission of instructor.

Credit Hour(s): 0 OR 5

Lecture Hour(s): 0 OR 1

Instruction Type(s): Lab, Lecture, Online Lecture

Instruction Type(s): Lab, Lecture, Online Lecture

Prerequisite(s): LAR 4705, LAR 4706

Corequisite(s):

LAR 5006:

Graduate Landscape Architecture Design Laboratory

Graduate landscape architecture laboratory addressing complex issues of landscape design and planning. The scope of planning and design includes the relationship of specific sites to their larger urban and/or regional contexts. Pre: undergraduate degree in landscape architecture or related field, or permission of instructor.

Credit Hour(s): 0 OR 5

Lecture Hour(s): 0 OR 1

Instruction Type(s): Lab, Lecture, Online Lecture

Instruction Type(s): Lab, Lecture, Online Lecture

Prerequisite(s): LAR 4705, LAR 4706

Corequisite(s):

LAR 5034G:

Advanced Evolution of the American Landscape

An examination of physical change in the rural and urban landscape of America as reflected by changes in needs during the country's history. Some of the factors influencing the character, form and use of American space that will be studied are economic growth, changing philosophies on conservation and exploitation of natural resources and their resulting legislation, technological advancement and social reform. Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

LAR 5044:

Land Analysis and Site Planning

Introduction to the concepts and methods of ecological resource survey and analysis at regional and site scales. Approaches to environmental problem solving with an emphasis on data collection, evaluation, and synthesis using applicable technologies such as geographic information systems. Interpretation of landscape resource data for the purpose of physical planning and design. I

Credit Hour(s): 0 OR 3

Lecture Hour(s): 0 OR 2

Instruction Type(s): Lab, Lecture, Online Lecture

Instruction Type(s): Lab, Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

LAR 5164:

TECT LAR I: Topo & Grading

Introduction to landscape architecture technology, focusing on the fundamentals of cartography, topography, grading, and landform manipulation. Graduate Standing required.

Credit Hour(s): 3

Lecture Hour(s): 2

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

LAR 5254:

Landscape Arch Theories

Critical examination of theories relevant to landscape architectural design and the inter-relationship among theory, practice, and research with special emphasis on contemporary theories. Evolution of theory with respect to built works. Overview of concurrent design theories and philosophies in the related arts. Graduate Standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

LAR 5264:

TECT LAR II: Site & Process

Links landscape architectural site design with environmental and construction processes. Conceptual site designs are developed through the production of documents for layout and grading of sites, stormwater management, and design and management of vegetative processes. Technical practices are framed within larger discourses of site conceptualization and representation.

Credit Hour(s): 3

Lecture Hour(s): 1

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): LAR 5164

Corequisite(s):

LAR 5304G:

ADV Topics in Landscape Arch

Complex issues facing the professional practice of landscape architecture today. Special emphasis on methods of analysis and interpretation including application of creative techniques, analogous thinking, computer-aided procedures and information handling in landscape architecture design and practice. Repeatable for a maximum of 9 credits. Pre-Requisite: Graduate Standing Required

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

LAR 5314:

Research Topics in LAR

Range and types of contemporary research within landscape architecture. Emphasis on literature, theories, methods, and case studies used in selected focused research areas. Graduate Standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

LAR 5334:

Landscape Architecture History

Historical development of landscape architecture with emphasis on

Emphasis on design theories, relationships between society and nature, conception of landscape by different social groups, and relationships between site design and urban design. Graduate Standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

LAR 5344:

Scholarship of Place

Theory and scholarly methods related to sense of place in landscape. Overview of theoretical literature and research on sense of place. Concepts and ideas of place-making in built works. Balancing human needs and environmental concerns while providing characteristics and qualities that impact sense of place. Development practices that lead to placelessness and jeopardize the integrity of our cultural environment. Scholarly methods in place research. Prerequisite: Graduate Standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

LAR 5364:

TECT LAR III: Material Constr

Links landscape architectural design, engineering, materials, and construction processes. Construction materials and assembly techniques. Preparation of landscape architectural drawings and specification. Methods of documentation are also covered, including conventional and digital communication technologies.

Credit Hour(s): 3

Lecture Hour(s): 2

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): LAR 5264

Corequisite(s):

LAR 5704:

Advanced Landscape Design and Planning Lab

Studio addressing advanced problems in landscape design and planning.

Credit Hour(s): 0 OR 5

Lecture Hour(s): 0 OR 1

Instruction Type(s): Lab, Lecture, Online Lecture

Instruction Type(s): Lab, Lecture, Online Lecture

Prerequisite(s): LAR 5006

Corequisite(s):

LAR 5724:

Scholarship in Landscape Architecture

An overview of scholarship in landscape architecture with emphasis on research approaches and methods pertaining to the advancement of knowledge in the profession. Application of ideas through the completion of a preliminary research project. Pre: Familiarity with landscape architecture or a closely allied environmental planning/design discipline. Non-majors by consent of instructor.

Credit Hour(s): 0 OR 3

Lecture Hour(s): 0 OR 2

Instruction Type(s): Lab, Lecture, Online Lecture

Instruction Type(s): Lab, Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

LAR 5754:

Thesis Studio

Thesis studio is an alternative to the conventional academic thesis for students pursuing a masters degree in landscape architecture. Thesis studio involves literature review, composition of a position paper grounded in design or planning theory and completion of studio projects(s) that test or demonstrate the theoretical position.

Credit Hour(s): 1 TO 19

Lecture Hour(s): 0 TO 19

Instruction Type(s): Lab, Lecture, Online Lecture

Instruction Type(s): Lab, Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

LAR 5774:

Advanced Graduate Design Lab

Advanced graduate landscape architecture studio addressing complex issues of landscape design and planning related to student focused research areas. Literature review grounded in design or planning theory. Completion of studio project(s) that test or demonstrate the design resolution of problems in the students research area.

Credit Hour(s): 6

Lecture Hour(s): 1

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): LAR 5314

Corequisite(s):

LAR 5964:

Landscape Architecture Field Studies

NONE

Credit Hour(s): 1 TO 12

Lecture Hour(s): 1 TO 12

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

LAR 5974:

Independent Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Independent Study, V11

Instruction Type(s): Independent Study, V11

Prerequisite(s):

Corequisite(s):

LAR 5984:

Special Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

LAR 5994:

Research and Thesis

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research

Instruction Type(s): Research

Prerequisite(s):

Corequisite(s):

LAR 7994:

Research and Dissertation

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research

Instruction Type(s): Research

Prerequisite(s):

Corequisite(s):

PLANNING, GOVERNANCE, AND GLOBALIZATION

Mehrzad Boroujerdi, Head

Emeriti Faculty: James Bohland;

Professors: Mehrzad Boroujerdi; Anne Khademian; Paul Knox; Ilja Luciak;

Timothy Luke; Joel Peters; Thomas Sanchez; Max Stephenson; Gerard Toal;

Edward Weisband; Kris Wernstedt;

Associate Professors: Ariel Ahram; David Bieri; Ralph Buehler; Margaret Cowell;

Giselle Datz; Matthew Dull; Ralph Hall; Laura Jensen; Robin Lemaire; Joseph

Rees; Patrick Roberts; Ioannis Stivachtis; Diane Zahm; Yang Zhang;

Assistant Professors: David Bredekamp; Steven Hankey; Chad Levinson;

Theodore Lim; Shalini Misra; Todd Schenk; Raymond Zuniga;

University Distinguished Professor: Paul Knox; Timothy Luke;

Edward S. Diggs Professor in the Social Studies: Edward Weisband;

Associate Professor of Practice: Elizabeth Morton;

School of Public & International Affairs: spia@vt.edu

Planning, Governance, & Globalization: <http://www.spia.vt.edu/phd-pgg>

Student Handbook: <http://www.spia.vt.edu/pgg/handbook>

The Ph.D. program in Planning, Governance and Globalization (PGG) is one of two Ph.D. programs available in the School of Public and International Affairs (SPIA), the other being the Ph.D. in Public Administration. The Ph.D. in PGG attracts students with widely differing backgrounds and interests. In order to accommodate this diversity, curriculum requirements are defined in two tracks with several thematic areas. These are: Urban & Environmental Design & Planning Track Thematic Areas: Metropolitan Development Community & Economic Development Planning International Development Planning Environmental Planning & Sustainability Landscape Planning & Landscape Analysis Transportation Planning Physical Planning & Urban Design Governance & Globalization Track Thematic Areas: Governance: Institutions & Civil Society Globalization: Identities, Security, & Economies

SPECIAL FACILITIES

SPIA is associated with one university-wide center (VCHR) and one SPIA institute (IPG). The Institute for Policy and Governance (IPG) facilitates and provides leadership in Virginia Tech's outreach mission to organizations in the Commonwealth's public and non-profit sectors, as well as national and international agencies. The Institute works with existing public service, extension, and outreach programs to respond effectively to existing demands on their services. The Institute identifies new opportunities for outreach, extension, and supporting research pertaining to administration, management, planning, and policy analysis

related to public and non-profit organizations. The Virginia Center for Housing Research (VCHR) has a mission to serve as "an interdisciplinary study, research, and information resource on housing for the Commonwealth of Virginia." Consulting on housing issues with the General Assembly, federal, state and local agencies, nonprofit organizations, private industry, and other colleges and universities, the Center also plays a role in the state's housing policy and research network. The Center provides data services related to housing to local and state governments, nonprofit organizations, and for-profit businesses. The Land Design and Simulation Lab conducts studies of the environmental impacts of proposed land alternations and proposes measures that can be implemented to mitigate adverse impacts.

DEGREES OFFERED

PhD Degree

Offered In (Blacksburg, National Capital Region)

TOEFL

Paper: (600.0)

Computer: (250.0)

iBT: (100.0)

Each doctoral student must complete a minimum of 90 semester hours of graduate study and a dissertation. All students are required to fulfill the requirements for their track or specialization and those of the Graduate School. The curriculum of this doctoral program will follow a flexible research-based program by requiring a small core of courses and by offering two major tracks, as well as thematic areas under each track. By the end of their first 24 credit hours in the program all students will be expected to have: (1) developed a plan of study; (2) selected a faculty advisory committee of a minimum four members; and (3) completed a "qualifying examination" by their faculty advisory committee. The qualifying examination ensures that the student is making satisfactory progress toward the degree. By the time students complete the preliminary exam, they must have met the Graduate School's Ethics Requirement. Meeting this mandatory requirement ordinarily will be satisfied by taking SPIA 6006 (Pedagogy) or in extraordinary circumstances, when SPIA 6006 cannot be taught, by other courses agreed to by the student's advisory committee.

Governance & Globalization Track Requirements The following courses can be used to meet the 12-hour, 4-course core requirements. Accordingly, all students would take 12 credit hours of common core courses: Pedagogy (3cr): SPIA 6006 or approved substitution. Theory (3cr): GIA/PSCI 6114: Critical Geopolitics or equiv. approved by advisor. Methods (6cr): GIA/PSCI 5115: Research Methods (3 hrs) and one (or more) of the following: GIA 5464: Qualitative Methods in Global Studies (3hrs) GIA/PSCI/UAP 5504: Discourse Analysis (3hrs) UAP 5224: Planning Methods and Technologies (Statistics) (3hrs) Also required: Research (30cr minimum): GIA 7994: Research and Dissertation. Urban & Environmental Design & Planning Track Requirements Students must have preparation in the diverse theoretical literatures that define the field and in both quantitative/analytic and qualitative/field research methods, as well as training in research design. Accordingly, all students would take 12 credit hours of common core courses: Pedagogy (3cr): SPIA 6006 or approved substitution. Theory (3cr): SPIA 6104: Planning Theory Seminar or approved substitution. (Take before Qualifying Exam). This seminar traces the epistemology of major contemporary theories of planning so as to situate the activity of modern planning in historical and intellectual contexts. Methods (6cr): UAP 5484: Research

Methodology (3cr), and UAP 5494 (Advanced Quantitative Techniques (3cr), or equivalents. Also required: Research (30cr minimum): UAP 7994: Research and Dissertation. Students pursuing thematic areas Landscape/Environmental Planning and Landscape Analysis will be required to complete two additional core courses, although these may be waived if students have already taken equivalent courses successfully. LAR 5314 -Contemporary Research Topics (3 credits) LAR 5344 - Scholarship of Place (3 credits) Following successful completion of the "qualifying evaluation" students continue to take coursework as outlined in their plans of study. At the completion of coursework, students will undertake the "preliminary examination", a formal assessment of each student's preparedness to pursue advanced graduate research. Within 60 days of passage of the preliminary examination, students must defend the dissertation proposal before his or her faculty advisory committee. Upon completion of the dissertation, the student must defend it before the committee. Graduate School policies and guidelines determine all other degree requirements.

PUBLIC ADMINISTRATION AND PUBLIC AFFAIRS

Karen Hult, Chair

Emeriti Faculty: Brian Cook; Larkin Dudley; Charles Goodsell; Gary Wamsley;

Professors: Karen Hult;

Associate Professors: Matthew Dull; Laura Jensen; Robin Lemaire; Joseph Rees; Patrick Roberts; Stephanie Smith;

Assistant Professors: David Bredenkamp; Adrienne Edisis; Eric Malczewski; Raymond Zuniga;

Assistant Professor of Practice: Stephanie Davis;

General Contact: mlechuga@vt.edu

General Contact: kcris@vt.edu

Center for Public Administration and Policy: <http://www.cpap.vt.edu/>

The mission of the Virginia Tech Center for Public Administration and Policy (CPAP) is to promote good governance and the advancement of capable and ethical public service by providing outstanding education, research and outreach in the theory and practice of public administration, management, and policy. CPAP seeks: To provide qualified public service professionals currently in service and pre- or early-career students who plan to become public service professionals with a rigorous program of study for developing managerial, analytical and normative evaluation skills in public management and public policy. To prepare teachers and scholars for faculty service in colleges and universities around the country and the world, thereby broadening the scope of knowledge in public administration and policy studies among administrators and citizenry. To engage faculty, practitioners, and graduate students in systematic research and study designed to improve the quality of policy making and public service within the varied jurisdictions of government in the Commonwealth of Virginia and the national capital region, as well as nationally and internationally. CPAP offers two degrees: the Master of Public Administration (MPA) and the PhD. in public administration and public affairs. The MPA is offered in Blacksburg, Arlington, and Richmond. The Ph.D. is offered in Blacksburg and Arlington. CPAP also is the home for two graduate certificates, in Homeland Security Policy and in Local Government

Management.

iBT: (80.0)

SPECIAL FACILITIES

Beyond the main campus in Blacksburg, Virginia, CPAP offers students opportunities to earn the MPA and the PhD in the rich learning environments of Arlington, VA (adjacent to Washington, DC) and Richmond, VA, the state capital (MPA only).

Beyond the Blacksburg campus

In addition to offering the MPA and PhD programs in Blacksburg, CPAP offers students opportunities to earn graduate degrees in the rich learning environments of Arlington, VA (M.P.A. and PhD) and Richmond, VA (MPA).

Thomas-Conner House

Situated just off the main Virginia Tech campus in downtown Blacksburg, VA, the historic, Thomas-Conner House is CPAP's headquarters and home to a thriving academic community for MPA and PhD students.

DEGREES OFFERED

PhD Degree

Offered In (Blacksburg, National Capital Region)

TOEFL

Paper: (550.0)

Computer: (213.0)

iBT: (80.0)

GRE

GMAT

A minimum of 90 credit hours is needed for the Ph.D. in Public Administration and Public Affairs. A maximum of one half of the coursework required for the CPAP Ph.D., or 30 of 60 credit hours, may be transferred from an accredited university other than Virginia Tech upon approval by two core faculty evaluating the student's program of study. The 60 credit hours of required coursework encompasses foundation courses, advanced topics and capstone courses, measurement courses, and research concentration courses. Students must also take 30 hours of research and dissertation credit, three hours of which must be constituted by participation in 15 sessions of the Doctoral Mentoring Program (DMP) or other activities approved by the faculty for DMP credit. Entering students must have completed courses in United States Government, Micro-economics, and Introductory Statistics with a grade of C+ or better. Students without all prerequisites completed must complete the missing prerequisites as soon as possible and before enrolling in PAPA 6224. We require all PhD applicants to submit scores from one of the following graduate admissions tests: GRE or GMAT.

MPA Degree

Offered In (Blacksburg, Richmond, National Capital Region)

TOEFL

Paper: (550.0)

Computer: (213.0)

All M.P.A. students must complete nine required 3-credit courses, plus three elective courses of their choosing, plus a portfolio for a total of 39 credit hours. Entering MPA students must have taken at least one undergraduate course on the institutions of U.S. government or have equivalent work experience or training. Test scores (GRE or GMAT) for MPA applicants are optional. VT undergraduates majoring in Smart and Sustainable Cities (SSC) or Environmental Policy and Planning (EPP), with a cumulative GPA of at least 3.5 and at least 90 credit hours of the undergraduate degree completed, may also apply for the Accelerated Undergraduate/Graduate degree program.

GRADUATE COURSES (PAPA)

PAPA 5014:

Concepts and Approaches to Public Administration

Covers the origins and development of the administrative state. Surveys major theoretical approaches to public administration. Discusses the problem of values in administration, the political environment of bureaucracy, and questions of ethical behavior in administration.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PAPA 5024:

Introduction To Public and Nonprofit Financial Management

Introduction to central concepts in financial management for public and nonprofit organizations. Accounting, financial statements and management reporting, auditing, internal control systems, accountability, and approaches to assessing the financial condition of public and nonprofit entities. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PAPA 5034 (UAP 5034) (GIA 5034):

Democratic Governance in the Economy

Interplay between democratic politics upon economic relations, with special focus on the intellectual foundations of capitalist development and consequences of financial disruption to economic policy making.

Evolution of state-market interactions and of global governance

institutions. Case studies of financial crises and their political implications. Pre: Graduate Standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PAPA 5044:

Local Government and the Professional Manager

Covers the origin and development of the administrative state. Surveys major theoretical approaches to public administration. Discusses the problem of values in administration, the political environment of bureaucracy and questions of ethical behavior in administration.

Particular attention given to the local government context and the local public managers role. Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PAPA 5214 (SOC 5214):

Research Methods

Research methods in sociology including survey methods, qualitative methods, and experimental design. The link between social theory and social research. Measurement, validity, reliability, and the logic of data analysis.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PAPA 5254:

Hmlnd Sec & Terrorist Threat

A multidisciplinary introduction to theory, strategy, decision making, and doctrine of Homeland Security as practiced in the U. S. Describes the threat, nature of current global conflicts in which the U. S. is engaged, Americas foreign and domestic policy responses to 9/11, and strategic and operational homeland security functions. Prerequisite: Graduate standing required

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PAPA 5315:

Government Administration

5315: The first of a sequence of two, provides theoretically grounded but practical knowledge on behavioral skills necessary for the public manager. These include the ability to lead, to supervise, to organize, and to communicate in public settings and in agencies serving the community and society. 5316: The second of a sequence of two, teaches the techniques and technology necessary to manage public organizations efficiently and effectively and to be held accountable for administrative actions and programs.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PAPA 5316:

Government Administration

5315: The first of a sequence of two, provides theoretically grounded but practical knowledge on behavioral skills necessary for the public manager. These include the ability to lead, to supervise, to organize, and to communicate in public settings and in agencies serving the community and society. 5316: The second of a sequence of two, teaches the techniques and technology necessary to manage public organizations efficiently and effectively and to be held accountable for administrative actions and programs.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PAPA 5354:

Hmlnd Sec & Response & Recovery

Multi-disciplinary policy course focused on emergency response and recovery following catastrophic manmade disasters in the U. S. Emphasis on strategic and operational decision making; response models and strategies; the preparations, response and recovery roles and responsibilities of federal, state and local jurisdictions; and federal

jurisdictional response planning and operation execution. Prerequisite:

Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PAPA 5614 (STS 5614):

Introduction to Science and Technology Policy

Strategies for science and technology policy; science education; scientific and technical information for societal uses; government and public policy; resource allocation; economy and global exchanges of science and technology; approaches to policy evaluation.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PAPA 5674:

Financial Health of Public and Nonprofit Organizations

Concepts and analytical capacities necessary to evaluate the overall level of financial health of governmental and nonprofit/nongovernmental organizations. Examines the tools and techniques necessary to assess the financial condition of the organizations and to determine if they have the capacity to carry out their purposes and address their debt obligations. Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PAPA 5694:

Asset Management for Public and Nonprofit Organizations

Provides an understanding of asset management for governmental and nonprofit/nongovernmental entities. Focuses on the essentials of cash budgeting and cash management, investment of endowments and pension funds, and debt management and debt financing for governmental and nonprofit/nongovernmental organizations. Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PAPA 5784:

Economic Development Planning Topics

An introduction to local economic development programs. Covers intergovernmental relations, financing techniques, federal and local subsidies, advertising, marketing, public relations, labor market issues, tax considerations, fiscal impact analysis, and land use planning issues. May be repeated with different topics for a maximum of 9 credits.

Graduate standing required.

Credit Hour(s): 1 TO 3

Lecture Hour(s): 1 TO 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PAPA 5904:

Project and Report

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research, Online Research

Instruction Type(s): Research, Online Research

Prerequisite(s):

Corequisite(s):

PAPA 5954:

Internship in Public Administration/public Affairs

For students without substantial previous management or staff experience and for students changing positions or career. Supervised work and academic experience.

Credit Hour(s): 1 TO 15

Lecture Hour(s): 1 TO 15

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PAPA 5974:

Independent Study

NONE

Credit Hour(s): 1 TO 19

472 Lecture Hour(s): 1 TO 19

Instruction Type(s): Independent Study, VI

Instruction Type(s): Independent Study, VI

Prerequisite(s):

Corequisite(s):

PAPA 5984:

Special Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PAPA 5994:

Research and Thesis

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research, Online Research

Instruction Type(s): Research, Online Research

Prerequisite(s):

Corequisite(s):

PAPA 6014:

Public Administration Theory

Examines the epistemological-ontological basis of public administration study; recent and current issues in the practice of public administration; and perspectives of the Center faculty concerning the direction of the field.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PAPA 6114:

Complex Public Organizations

Examines the principal conceptual and theoretical bases for understanding the structure and environment of complex public organizations; also explores the problems bureaucracy poses for democratic theory and for vigorous economy.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PAPA 6154:

Advanced Topics in Public Organizations

Selected topics of theory, methodology, and design in current research literature on complex public organizations and large-scale bureaucratic systems. The political environment of such systems will be emphasized.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PAPA 6214:

Public Policy Processes and Analytical Approaches

Examines in a general way, the field of public analysis in and for government. Covers the traditions and assumptions of the field; notes and critiques the literature; examines relationships to other fields and topics of public administration; and discusses the processes of policy-making and techniques of analysis.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PAPA 6224:

Design, Implementation, and Evaluation of Public Policy and Programs

The general purpose of this course is to develop an understanding of the process by which policy is formulated, analyzed, implemented, and evaluated. The focus will be on such actions as undertaken by policy analysts in and out of government. The methodological issues and techniques used to accommodate the major social, economic, political, and behavioral aspects of policy analysis in an organizational context will be discussed.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PAPA 6254:**Advanced Topics in Public Policy**

Selected topics in public policy analysis and program evaluation.

Theoretical perspectives, methodological issues, and current research on selected policies and programs at international, national, or subnational levels, etc.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PAPA 6264:**Advanced Topics in Policy Systems Management**

Focus on critical integration of policy and management concerns in national strategy that represent a point of synthesis of external and internal policy arenas in such selected areas as: national and international security, politico-economic risk in overseas operations of U.S. institutions, crisis and emergency management, technoscience and resource systems, and information resource systems.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PAPA 6294:**Capstone Seminar in Public Policy**

Conceptualization and research into the processes of policy analysis and program evaluation in the public sector. Selected conceptual, methodological, organizational, and ethical problems associated with the analysis, implementation, and evaluation of public policies and programs.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PAPA 6314:**Public Budgeting Processes and Their Policy Implications**

Surveys the public budgeting processes of public organizations. The contrasting norms and behaviors of participants, their impacts on policy, and their implications for democracy are examined. Processes studied

include the work of budgeteers, decision making processes, control and financial accounting, and intergovernmental interaction.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PAPA 6324:**Public Personnel Processes and Their Policy Implications**

Surveys the key personnel processes of public organizations, the contrasting norms and behaviors of participants, their impacts on policy, and their implications for democracy.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PAPA 6344:**Ldrship & Mgt Process Pub Adm**

Conceptual and theoretical bases for understanding leading and managing in the context of public organization processes and functions such as budgeting and financing human resource management, acquisitions, information technology, and planning. Pre-requisite: Graduate Standing required

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PAPA 6354:**Advanced Topics in Public Management**

An examination at an advanced level of a selected managerial process in the public sector (civil and military), the norms and participant behavior associated with the process, its efficacy in planned change, and its overall impact on policy making and implications for democracy.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PAPA 6394:**Capstone Seminar in Public Management**

Original conceptualization of and research into specific aspects of management processes in the public sector. Opportunities and problems in using management processes to institute planned change.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PAPA 6414:**Normative Foundations of Public Administration**

The course will examine the discretionary judgments of administrators as the central normative issue in the field of public administration and will look to constitutional principles for guidance in the responsible exercise of administrative discretion. Particular emphasis will be placed on selected court decisions to compare and contrast legal and moral reasoning.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PAPA 6454:**Advanced Topics in Ethics and the Public Sector**

This is an advanced course in the Centers curriculum area dealing with ethics and the normative theory of the state. It will examine the theoretical basis of ethical standards in the field of public administration. Special emphasis will be placed on the Ethics in Government Act of 1978 and the Code of Ethics of the American Society for Public Administration.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PAPA 6514:**Public Administration and Policy Inquiry**

Provides students with a general background in the design and execution of inquiry in public administration and policy. Includes

examination of concepts, issues and problems of inquiry design, measurement, data collection, analysis, and the application of computers, and other information processing tools to support research and decisionmaking in public administration and policy.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PAPA 6524:**Advanced Quantitative Methods in Public Administration & Policy**

Advanced quantitative methods for the public administration and policy, including logit and probit models, factor analysis, structural equation models, and social network analysis.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): PAPA 6514

Corequisite(s):

PAPA 6664 (STS 6664):**Advanced Topics in Science and Technology Policy**

Variable topics in science and technology policy. Includes advanced study of science, technology, and economy; science, technology, and power; strategies for research and development policy --public and private sector; transfer of technology; technological forecasting; government regulation and responses; science policy assumptions and challenges, specialist knowledge and expertise; state and academic knowledge production; issues of race, class, gender, and national identity in policy work. May be repeated with a different topic for a maximum of 6 credits.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PAPA 6984:**Special Study**

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

475 Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PAPA 7954:

Internship in Public Administration/public Affairs

For students without substantial previous management or staff experience and for students changing positions or career. Supervised work and academic experience.

Credit Hour(s): 1 TO 15

Lecture Hour(s): 1 TO 15

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PAPA 7964:

Field Study

Applied research and/or evaluation study in cooperating government agency as part of a team of advanced graduate students and faculty.

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PAPA 7994:

Research and Dissertation

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research, Online Research

Instruction Type(s): Research, Online Research

Prerequisite(s):

Corequisite(s):

URBAN AND REGIONAL PLANNING

Ralph Buehler, Chair

Steven Hankey, Associate Chair

Emeriti Faculty: James Bohland; John Randolph;

Professors: Thomas Sanchez; Max Stephenson; Kris Wernstedt;

Associate Professors: David Bieri; Ralph Buehler; Margaret Cowell; Ralph Hall;

Shalini Misra; Diane Zahm; Yang Zhang;

Assistant Professors: Steven Hankey; Theodore Lim; Todd Schenk; Thomas Skuzinski; Wenwen Zhang;

Adjunct Professors: Shelley Mastran;

Professor of Practice: Elizabeth Morton;

Graduate Contact: ralphbu@vt.edu

Graduate Contact: hankey@vt.edu

Graduate Contact: ralphbu@vt.edu

UAP Home: <https://spia.vt.edu/programs/uap.html>

Graduate Site: <https://spia.vt.edu/degree-courses/graduate/murp.html>

The Master of Urban and Regional Planning (MURP) program is a two-year (48 credit hour) interdisciplinary professional degree open to students from a wide variety of undergraduate fields. The program's mission is to prepare students to become professional planners who can address the economic, environmental and social consequences of growth and change; and to provide leadership in fostering a more just and sustainable world through our teaching, scholarship, and service. The required core courses provide a foundation of planning theories and skills and constitute approximately one-half of the MURP curriculum. The remaining credit hours are selected by students and their advisors to develop individualized areas of specialization using coursework from across the university. Graduates are able to assume professional responsibilities in a wide variety of positions in public service or in the private sector. The program is accredited by the Planning Accreditation Board. The UAP graduate program is offered in two locations: the main campus in Blacksburg and in Arlington (Washington, DC metro area).

SPECIAL FACILITIES

Architecture Annex in Blacksburg and; Virginia Tech Research Center (VTRC) 900 N. Glebe Road, Arlington, VA, Northern Capitol Region (NCR) beginning with the fall 2019 semester.

Architecture Annex, Blacksburg

In Blacksburg the MURP degree is offered in the Architecture Annex. The Architecture Annex is the main administrative building for the School of Public and International Affairs and houses the Government and International Affairs and Urban Affairs and Planning programs of the College of Architecture and Urban Studies. The building was erected in 1916 as Blacksburg High School. It includes a computer lab and classrooms with wi-fi and video-conferencing capabilities.

VTRC (Virginia Tech Research Center)

In the Washington, DC metro area, the MURP degree is offered at the Virginia Tech Research Center (VTRC) in Arlington, VA. The VTRC comprises a seven-floor, 144,000-square-foot LEED-certified facility, with direct fiber access to Internet 2 and multiple federal networks. High-performance connectivity links this research center to Virginia Tech's main campus in Blacksburg, as well as to other major universities. The network provides access to international peering points in New York, Chicago, Seattle, Los Angeles, and Florida, and the building includes a secure data center for high performance computing (HPC)-based

research. All rooms have wi-fi, projection facilities, external phone line access, and video-conferencing capabilities—equipment available to support research includes an 18-seat networked computer laboratory. The VTRC represents the hub of Virginia Tech's research activities in the National Capital Region and has been designed to further the university's mission to expand its research portfolio and partnerships with corporate research entities, federal agencies, and other public and private-sector organizations. Other labs and centers housed at the VTRC include the Advanced Research Institute, Arlington Innovation Center for Health Research, Center for Energy and the Global Environment, Computational Bioinformatics and Bioimaging Laboratory, Crowd Intelligence Lab, Discovery Analytics Center, and the Hume Center for National Security and Technology.

DEGREES OFFERED

MURPL Degree

Offered In (Blacksburg, National Capital Region)

TOEFL

Original Test: (550.0)

IELTS: (6.5)

IBT Test: (90.0)

GRE

Old Exam: Verbal (530.0), Quantitative (630.0)

Current Exam: Verbal (155.0), Quantitative (150.0)

MURP students must take 48 credit hours of work, with a 3.0 GPA or better. These credit hours are divided into the planning "core" courses, plus the individualized area of specialization. The core requirements include: UAP 5014 Gateway to Planning UAP 5084 Collaborative Planning and Community Involvement UAP 5174 Planning Theory and History UAP 5224 Planning Methods and Technologies UAP 5234 Urban Economy, Equity, and Society UAP 5554 Land Use Law and Planning UAP 5125-5126 Planning Studio: Real World Problems and Solutions or UAP 5994 Research and Thesis Applying for Admission: Interested students should use Graduate School's on-line system to apply. The MURP program does not require GRE scores of students with a degree from a university in the US and further requires applicants to submit an on-line application form, application fee, official transcripts of previous academic work, personal statement, three (3) letters of recommendation, and resume. In addition, all applicants who did not earn an undergraduate degree from a university in the US must submit GRE scores, and all international applicants whose first language is not English must submit TOEFL scores (see <http://graduateschool.vt.edu/applying> for Graduate School requirements). Note that the Graduate School requires a minimum cumulative grade point average for admission of 3.0 or better. This requirement may be relaxed based on an applicant's professional experience and accomplishments. Advanced undergraduates may apply for early admission into the accelerated undergraduate/graduate degree program, the combined architecture program, or for dual enrollment status. Interested undergraduate students should meet with an academic advisor to determine eligibility. Please also see admissions information provided on the Graduate School website. Simultaneous degrees :

MURP students have the ability to pursue simultaneous master's degrees in other departments, for example, Natural Resources, Public Administration, or Landscape Architecture. The student must apply and be accepted into both programs, have an approved plan of study for each degree, and submit an Application for Simultaneous Degrees to the Graduate School. Graduate Certificates : The Graduate School at Virginia Tech offers a wide array of graduate certificates that are available to MURP students. Many students use a certificate program as the foundation for an individualized area of specialization related to the MURP degree. Urban Affairs and Planning offers certificates in Economic Development, Global Planning and International Development, and Metropolitan Studies, and participates in several others (Social, Political, Ethical and Cultural Thought, or ASPECT; Geospatial Information Technology; Nonprofit and Nongovernmental Organization Management; Public and Nonprofit Financial Management; and Watershed Management). MURP students have completed certificates in a variety of other areas as well. More information on graduate certificates is available from the Graduate School.

GRADUATE COURSES (UAP)

UAP 5004 (GIA 5004):

Power and Policy in the US

Social science theory and research on the distribution of power in the US, especially as it shapes important national policy outcomes. Institutional and class bases of power will be examined, including membership on corporate boards and in policy-shaping think tanks. Implications for democracy in society will be drawn. Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

UAP 5014:

Gateway to Planning

Careers in planning in the public, private and non-profit sectors. Planning practice in different contexts and governance systems. Planning ethics, community and stakeholder engagement, social justice, and professional regulations. Social, physical, environmental, economic, and other dimensions of complex planning problems. Professional skill development, with a focus on written, oral, visual, and digital communication, including social media in planning. Pre: Graduate Standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

UAP 5034 (GIA 5034):

Democratic Governance in the Economy

Interplay between democratic politics upon economic relations, with special focus on the intellectual foundations of capitalist development and consequences of financial disruption to economic policy making. Evolution of state-market interactions and of global governance

institutions. Case studies of financial crises and their political implications. Pre: Graduate Standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

UAP 5064G:

Adv Pollution Cntrl Plan & Pol

Planning and policy aspects of managing residuals and environmental contaminants and their effects on human health and environmental quality. Technical and economic factors involved in management of water quality, air quality and solid and hazardous wastes, toxic substances, and noise. Implementation of pollution control legislation, policies, and programs at federal, state and local levels.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

UAP 5074G:

Adv Comm Renewable Energy Sys

Critical review of energy issues from local to international including economic, environmental, and social dimensions. Introduction to energy science, engineering, and economics. Application of energy and economic analysis to efficient and renewable energy systems in buildings, electricity, and transportation. Review and assessment of energy planning and policies for efficient and renewable energy at the local, state, and national levels. Prerequisite: Graduate Standing required

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

UAP 5084:

Collaborative Planning and Community Involvement

Public participation in planning and decision-making. Deliberative democracy and citizen empowerment. Tools for and approaches to community involvement and alternative dispute resolution. Facilitation and engagement process design. Opportunities and challenges associated with engaging communities in planning and decision-making.

Pre: Graduate Standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

UAP 5104:

Urban and Regional Development Theory

An examination and critique of theories relating to socio-economic development and change at three major scales (international, national/regional, and intra-urban) and of theories relating to the linkages between the dominant processes operating at these major scales. Particular emphasis is given to the role of the state in urban and regional development.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

UAP 5114:

Computer Applications in Urban Planning and Management

An examination of a wide range of computer-based techniques that are of value in analyzing urban and regional planning and management problems. Techniques include linear programming, goal programming; modeling of complex systems; and decision modeling. May be repeated with different content for a maximum of 12 credits.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): UAP 5224

Corequisite(s):

Urban and Regional Planning Studio

Application of planning strategies to solve urban problems encountered in professional practice. Includes methods and techniques for securing and analyzing relevant data; identifying goals and objectives; formulating proposals; formulating strategies to implement proposals; presentation of findings. May be repeated with a different studio application for a maximum of 6 credits.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

UAP 5125:

Planning Studio: Real World Problems and Solutions

5125: Individual and collaborative group work on a community client-based project. Project management. Problem identification, data collection and analysis, community/stakeholder engagement. Professional norms and practices. 5126: Data analysis and visualization. Proposal of potential solutions to client-based planning problem. Preparation of a written report. Oral presentation.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): UAP 5014, UAP 5084, UAP 5174, UAP 5224, UAP 5234, UAP 5554

Corequisite(s):

UAP 5126:

Planning Studio: Real World Problems and Solutions

NONE

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): UAP 5125

Corequisite(s):

UAP 5134G:

Advanced Land Use and Environment: Planning and Policy

Environmental factors involved in land use planning and development, including topography, soils, geologic hazards, flooding, and storm water management, ecological features and visual quality. Techniques for conducting environmental land inventories and land use suitability analyses. Policies and programs to protect environmental quality in land

use planning. Prerequisite: Graduate Standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

UAP 5164:

Collaborative Governance and Civil Society

Theoretical foundations of collaborative policy and governance approaches are examined. Strategies and methods for forming and sustaining collaborative coalitions are discussed. Case studies are used to illustrate the effectiveness of collaborative approaches in different policy domains.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

UAP 5174:

Theory and Practice of Urban and Regional Planning

Key planning theories and the history of planning thought and planning practice. Critical perspectives on the challenges and issues facing contemporary planning practice. Milestone events, themes, and debates in the history of planning and their influence on current planning thought and practice. Subfields and specializations in urban planning. Ethical issues in planning. Effective communication tools and techniques. Pre: Graduate Standing

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

UAP 5184:

Local Government Planning Management and Administration

Leadership best practices and the skills of the local government planning manager. Planning office organization and operations. Planning ethics and ethical leadership. Legislative, statutory, and legal context for planning. Politics and planning. Visioning and goal setting. Developing partnerships and opportunities for collaboration. Stakeholder management and conflict resolution. Data, analytics, and information technology in planning. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

UAP 5194:

Urban Growth Mgmt

Examines regulatory and financial techniques for controlling and guiding urban development. Evaluates their advantages and disadvantages with respect to development circumstances. Focus is primarily on the practice of local and state governments in the U.S.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): UAP 4754

Corequisite(s):

UAP 5214:

Topics in Natural Resources and Natural Hazards Planning

Concepts, theory, and practice of resilience-based, climate- change integrated natural resources management and hazards planning. Effects of land, water, soil, and ecosystem management on quality of life for present and future generations. Natural resources and natural hazards planning process and tools for local communities and policies at state and federal levels. May be repeated for a maximum of 9 credit hours.

Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

UAP 5224:

Planning Methods and Technologies

Quantitative and qualitative methods pertaining to urban and regional planning and analysis; types of data, data sources and data preparation; survey research; technologies for urban planning and analysis; ethics in planning methods. Pre: Graduate Standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

UAP 5234:

Urban Economy, Equity, & Society

Urban and regional political economy and finance. Interactions and effects of economic forces and political institutions on urban policy and governance, as well as physical and social infrastructure and inequities. Urban growth and change, institutions of local and federal government and governance, real estate markets, equity, and institutional access. Urban finance, taxation policy and local revenue sources. Pre: Graduate Standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

UAP 5244:

Multicultural

Examines the growing ethnic and demographic diversity of urban United States. Stresses theories and techniques that can be used to bring about more inclusive planning and public policies at all levels of government.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

UAP 5264G:

Advanced Environmental Ethics and Policy

Issues in applied environmental ethics. Contributions of multi-cultural religious and spiritual traditions to contemporary perspectives on the human-nature relationship. Examination of selected issues in environmental ethics from utilitarian economic, deep ecology, and ecofeminist perspectives. Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

UAP 5274:

Comparative Social Movements

480 This course will investigate the forms of public protest that occur all over

the world, with special attention to activism in poor nations and to the recent emergence of transnational movements. Also examines why and when governments repress social movements. Explores movements that are grounded in collective identities based in class, race/ethnicity, gender, religion, and culture. Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

UAP 5304:

Land Use Planning

Procedures for: (1) identifying the type, magnitude, and locational characteristics of urban land uses; (2) making projections of future land use; and (3) preparation of land use plans.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

UAP 5324:

Topics in Infrastructure Planning in Developing Countries

Introduction to infrastructure planning and development practices in developing countries. Study of practices to address the complex challenges facing many developing regions. The current state of practice for the provision of infrastructure services. Role of public/private local, regional, and national planning/development agencies and international organizations and groups. May be repeated with different topics for a maximum of 9 credits.

Credit Hour(s): 1 TO 3

Lecture Hour(s): 1 TO 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

UAP 5354:

Charity, Philanthropy and Civil Society

This course treats the evolution of philanthropy and charity in the United States and abroad and introduces major issues and continuing concerns linked to the institutions engaged in these activities while exploring their ties to civil society. Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

UAP 5364:

Non-Governmental Organizations in International Development

Explores theory and cases of non-governmental organizations in international development. Analyzes various roles of NGOs, and their interactions with local communities, government agencies, international organizations, and private businesses. Examines tensions and collaborations between NGOs and other development actors, drawing from cases in environmental, health, and educational policy domains.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

UAP 5414:

Natural Resources Planning Topics

The natural resource planning process as implemented by federal public lands and water resources agencies in the U.S. Public participation, environmental impact assessment, and resource evaluation methods used in planning and decision-making. Applications to resources planning in developing countries. May be repeated with different topics for a maximum of 9 credits. Graduate standing required.

Credit Hour(s): 1 TO 3

Lecture Hour(s): 1 TO 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

UAP 5424:

Metropolitan Planning Topics

A topics course focusing on the methods and techniques of evaluating physical development needs of metropolitan areas their sub-areas. Emphasis on elements of land use, physical development needs, representation, and the role of comprehensive plans and implementing regulatory ordinances (zoning, land subdivision regulations, building codes, environmental regulations). May be repeated with a different topic for a maximum of 12 credits.

Credit Hour(s): 1 TO 3

Lecture Hour(s): 1 TO 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

UAP 5434:

Urban Development Project Review Studio

A studio focusing on the theory, methods, and techniques of evaluating physical development projects. Emphasis on evaluation criteria implied in public policy, as expressed in comprehensive plans and implementing regulatory ordinances (zoning, land subdivision regulations, building codes, environmental regulations).

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

UAP 5454:

Nonprofit Organization & Management

Examines the nonprofit sector in American society and compares those roles with the roles the sector plays in other advanced democracies as well as in developing countries. Also analyzes the role of important sub sectors within the nations third sector and explores key management challenges confronting non-profit organization leaders with them. Compares those challenges to those found in nongovernmental organizations in developing nations. Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

UAP 5464 (GIA 5464):

Qualitative Research Methods in Global Studies

Examines the philosophies and procedures guiding various qualitative methods used in the social science fields, such as global studies, planning and policy. Exploration of alternative understandings of normal science and consideration of the merits of adopting qualitative research approaches to disciplined analysis, including ethical issues in research. Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

UAP 5484:

Advanced Urban Research Methodology

The various methodological approaches used in the fields of urban planning and in public policy to analyze causes of problems and thus suggest policy recommendations. Emphasis is on defining the research problem, developing an appropriate research design, data collection, and fundamental techniques of data analysis.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

UAP 5494:

Advanced Quantitative Techniques for Urban Research

Advanced quantitative techniques used in urban analysis. Application of the methods to situations encountered in urban planning, urban policy analysis, and urban management are stressed.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): UAP 5484

Corequisite(s):

UAP 5504 (GIA 5504) (PSCI 5504):

Discourse Analysis

Examines the key theoretical sources and major practical applications of discourse analysis as a contemporary social science methodology. Origins, major variants, and critical uses of discourse analysis in cultural studies, semiotic methods, policy analysis, and organizational communication techniques also are considered. Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

UAP 5524 (GIA 5524):

Internat Development

Social and cultural factors in the development of societies, including the 482 role of women in development. Contemporary developing countries, and

historical material from developed countries; policy issues facing governments of developing countries and those interested in assisting their development.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

UAP 5554:

Land Use Law & Planning

Fundamentals of law as it applies to the use of land, with a primary focus on its practice in the United States. Comparative land use law. Case law and statutory law briefing. Constitutional and statutory limitations on regulation; common law principles; traditional use-based zoning and zoning processes and documents; alternative approaches to planning and zoning such as smart growth techniques and form-based codes; and the relationship between land use regulation and urban/metropolitan issues, such as social segregation, sustainability, and environmental justice. Pre: Graduate Standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

UAP 5564:

Information Technology, Society, and Public Policy

Social impacts of new and emerging information technologies from a public policy perspective. Technical nature of IT and influences of IT on four core dimensions of society: political, economic, cultural, and spatial. Course integrates theoretical and philosophical literature on IT with applied policy and planning issues.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

UAP 5574:

Arts, Culture and Society

Considers the role of the arts in society, including architecture, music companies, or theater productions to heritage sites, science museums, and art galleries. Effective arts policy in revitalizing urban economies

also examined. Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

UAP 5584 (GIA 5584) (PSCI 5584):

Environmental Politics and Policy

Course provides a broad introduction to the key ideas, actors and institutions related to environmental politics and policy in the United States, with some coverage of global issues. It is intended to provide students with basic interdisciplinary knowledge and an intellectual framework for understanding and thinking critically about environmental politics and policy.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

UAP 5594:

Nonprofit Law and Ethics

Explores the legal, ethical and normative systems affecting nonprofit and nongovernmental organizations, both domestically and internationally. Examines the historical foundations of legal regulation and professional ethics within the sector and how these systems contribute to the administration and governance of nonprofit and nongovernmental organizations. Also surveys current theories of nonprofit/nongovernmental organization regulation as well as major legal and ethical issues confronting the sector. Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

UAP 5604:

Housing Planning and Policy Topics

An examination of national and local housing markets with emphasis on the impact of various public housing policies on the demand for and supply of housing within these markets. The relationships between public and private delivery systems. May be repeated with different topics for a maximum of 9 credit hours. Graduate standing required.

Credit Hour(s): 1 TO 3

Lecture Hour(s): 1 TO 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): UAP 5234

Corequisite(s):

UAP 5614:

Topics in City Design Policy

Topics course on the history and theory of city design and the policies that govern design. Design and policy terminology. Identification and selection of policy tools and techniques in various contexts, and to address specific problems of city design. Advantages and disadvantages of city design policy tools. Issues of implementation and administration related to city design policy. May be repeated 2 times with different content for a maximum of 9 credits. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

UAP 5624:

Urban Design Seminar

Current topics in urban design. Topics may include: theoretical, conceptual and practical concerns in the generation of urban spatial form; the roles of public and private interests in shaping urban form; the effects of urban intensification on the quality of public spaces; environmental issues in urban design; the role of public policy and regulatory mechanisms; the genesis and development of urban typologies. Each seminar will address one of these or related subject areas. Course may be repeated with a different subject for a maximum of 12 credits.

Credit Hour(s): 1 TO 3

Lecture Hour(s): 1 TO 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

UAP 5634:

Urban Design Studio

Urban design studio projects involving the translation of design and planning theory and methodology to actual form-giving proposals for the urban context. Emphasis will be on the development of urban tectonic form in response to functional and behavioral planning, symbolic and

aesthetic factors. May be repeated for a maximum of 12 credit hours.

Credit Hour(s): 0 TO 12

Lecture Hour(s): 0 TO 12

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ARCH 4715

Corequisite(s):

UAP 5644:

Transportation Systems Planning

Advanced consideration of problems dealing with transportation systems as they affect the socio-economic development of cities, regions, and nations; the travel behavior of a populace; the location of economic activity; the use of land; and the allocation of resources.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

UAP 5674:

Financial Health of Public and Nonprofit Organizations

Concepts and analytical capacities necessary to evaluate the overall level of financial health of governmental and nonprofit/nongovernmental organizations. Examines the tools and techniques necessary to assess the financial condition of the organizations and to determine if they have the capacity to carry out their purposes and address their debt obligations. Graduate Standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

UAP 5764:

International Development Studio

International development project initiation and institutional framework; project design processes, criteria, and methods; implementation and evaluation design processes, criteria, and methods. Examination of case projects by public and private donor agencies as a basis for project design.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): UAP 4764

Corequisite(s):

UAP 5764G:

Advanced International Development Planning and Policy

Examination of major development theories and contemporary issues and characteristics of low-income societies (industrialization, urbanization, migration, rural poverty, hunger, foreign trade, and debt) that establish contexts for development planning and policy-making.

Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

UAP 5774:

Econ Develop Studio

Principles, concepts, and techniques related to economic development at either the local and regional scale are brought to bear in solving a development problem. Emphasis is on problems which are encountered in planning or implementing economic development.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): UAP 5234 OR UAP 5104

Corequisite(s):

UAP 5784:

Economic Development Planning Topics

An introduction to local economic development programs. Covers intergovernmental relations, financing techniques, federal and local subsidies, advertising, marketing, public relations, labor market issues, tax considerations, fiscal impact analysis, and land use planning issues.

May be repeated with different topics for a maximum of 9 credits.

Graduate standing required.

Credit Hour(s): 1 TO 3

Lecture Hour(s): 1 TO 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

UAP 5794:

Environ Plan Studio

Application of environmental planning techniques involving either land use or residuals management in a specific project.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

UAP 5804:

Practicum Problem

The practicum is one option (together with the major paper and thesis) which MUA and MURP Degree candidates may elect to complete their degree requirements. It is intended to provide the candidate with an opportunity to demonstrate: (1) a required degree of comprehension of the concepts, principles and techniques relevant to these fields, and (2) the ability to apply this understanding in a professional manner in a situation which simulates professional practice.

Credit Hour(s): 2

Lecture Hour(s): 2

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): UAP 5124 OR UAP 5144

Corequisite(s):

UAP 5854G:

Adv Plan Urban Infrastructure

Elements of the built environment and the policy/planning structure of the city. Elements associated with the primary urban activities (residential, commercial, industrial), as well as the urban form-giving infrastructure facilities that support those land uses (water supply, sewerage, solid waste disposal, transportation, education, recreation, health, and safety). Prerequisite: Graduate Standing required

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

UAP 5864:

Topics in Transportation Policy and Planning

Overview of major policy and planning issues in transportation; interdependence of transportation with land-use patterns. Analysis of problems of transportation systems, and alternative solutions examined in the context of the changing political/institutional environment. May be

Graduate Standing required.

Credit Hour(s): 1 TO 3

Lecture Hour(s): 1 TO 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

UAP 5894:

Final Examination

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

UAP 5904:

Project and Report

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research

Instruction Type(s): Research

Prerequisite(s):

Corequisite(s):

UAP 5914:

Peace Corps Service

Critical evaluation and field-based study of selected complex issues related to society in international context; study of cultural and language diversity; approaches to ethnoinclusiveness in urban and suburban environments; focus on practical local and regional planning for the benefit of local communities in consort with non-profit organizations, governments and global networks. Prerequisite: Graduate Standing and enrollment in the Masters International Program and Peace Corps.

Credit Hour(s): 6

Lecture Hour(s): 6

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

UAP 5924:

Peace Corp Enrollment

NONE

Credit Hour(s): 0

Lecture Hour(s): 0

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

UAP 5954:

Study Abroad

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

UAP 5964:

Field Study

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

UAP 5974:

Independent Study

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Independent Study

Instruction Type(s): Independent Study

Prerequisite(s):

Corequisite(s):

UAP 5984:

Special Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

UAP 5994:

Research and Thesis

Credit Hour(s): 1 TO 19

Lecture Hour(s):
Instruction Type(s): Research
Instruction Type(s): Research
Prerequisite(s):
Corequisite(s):

UAP 6984:

Special Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

UAP 7994:

Research and Dissertation

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research

Instruction Type(s): Research

Prerequisite(s):

Corequisite(s):

AGRICULTURAL AND APPLIED ECONOMICS

Matthew Holt, Head

Professors: Jeffrey Alwang; Darrell Bosch; Kevin Boyle; Richard Crowder; George Davis; Michael Ellerbrock; Leighton Geyer; Achla Marathe; Mary Marchant; Bradford Mills; Klaus Moeltner; George Norton; James Pease; Everett Peterson; Stephen Stephenson;

Associate Professors: Jason Grant; Gordon Groover; Olga Isengildina Massa; Wen You;

Assistant Professors: Catherine Larochelle; Kimberly Morgan; Travis Mountain; Clinton Neill; Ford Ramsey;

Professor and Thornhill Endowed Chair in Agricultural Trade: Richard Crowder;

General Contact: nadams10@vt.edu

Student Handbook:

http://aaec.vt.edu/content/dam/aaec_vt_edu/graduate/academic-information/StudentPLanningGuide2016-v3.pdf

The Department of Agricultural and Applied Economics (AAEC) offers a strong and growing graduate program that provides exciting study and research opportunities for students and has an outstanding record of graduate student placement. AAEC offers a M.S. in Agricultural and Applied Economics and a Ph.D. in Economics jointly with the Department of Economics. The Master's degree focuses on applied economics. A student may select courses that build upon a broad-based undergraduate economics curriculum or may specialize in a specific field of interest. By their choices among core courses and use of various electives, students may develop specialties in diverse areas including, but not limited to General Economics, Econometrics and Quantitative Methods, Food and Health Economics, Natural Resource and Environmental Economics, Food System Economics and Management, Policy and International Trade, and Economic Growth and Development. The M.S. degree offers both thesis and non-thesis options. Students enrolled in the Ph.D. program may use their Ph.D. coursework to simultaneously earn a master's degree. In the joint Ph.D. program with the Department of Economics, Ph.D. students take a common set of core courses in the first three semesters of the program and a common written qualifying examination. AAEC Ph.D. students then complete field courses in each of their two major fields, and elective courses that support their areas of research specialization. AAEC offers fields in: - applied econometrics, - environmental and resource economics, - food and health economics, - international development and trade, and - rural and regional development. Graduate students pursuing M.S. and Ph.D. degrees are eligible for graduate teaching assistantships and graduate research assistantships.

SPECIAL FACILITIES

Students on assistantship are allocated office space in the department and offices are made available to those students not on assistantship as space allows. All students have access to a well-equipped graduate computer laboratory with microcomputers, laser printers, and scanners. Many graduate students are allocated personal computers in their office facilities. Computers are networked to servers, which provide a wide variety of word processing, statistical, spreadsheet, mathematical programming, and other software.

Agricultural and Applied Economics Facilities Introduction

Students on assistantship are allocated office space in the department and offices are made available to those students not on assistantship as space allows. All students have access to a well-equipped graduate computer laboratory with microcomputers, laser printers, and scanners. Many graduate students are allocated personal computers in their office facilities. Computers are networked to servers, which provide a wide variety of word processing, statistical, spreadsheet, mathematical programming, and other software.

DEGREES OFFERED

MS Degree

TOEFL

Paper: (620.0)

Computer: (260.0)

iBT: (105.0)

GRE

General Test: Verbal (153.0), Quantitative (144.0)

M.S. degree: The general requirements for the master's degree thesis option are: (1) a minimum of 32 semester hours, including 26 hours of coursework and 6 hours of research and thesis (AAEC/ECON 5994), (2) completion of a thesis acceptable to the student's advisory committee, and (3) satisfactory performance on a final oral examination. The general requirement for a M.S. degree with applied economics focus non-thesis option is a minimum of 30 semester hours of coursework of which at least 24 hours must be at the 5000-level or above. For the M.S. degree, a student must also pass a final oral or written examination.

PhD Degree

TOEFL

Paper: (620.0)

Computer: (260.0)

iBT: (105.0)

GRE

General Test: Verbal (500.0), Quantitative (500.0)

Ph.D. degree: The Graduate School requirements for a Ph.D. degree include a minimum of 90 semester hours of graduate credit beyond the baccalaureate, with at least 27 hours of coursework and 30 hours of Research and Dissertation (AAEC/ECON 7994). For the Ph.D. degree in Economics, there are additional core coursework requirements. In the first year of the program, the core requirements include one semester each of mathematical economics and macroeconomic theory, and two semesters of microeconomic theory and econometric theory. In the second year of the program, the core requirements include one semester of applied microeconomic theory, one semester of microeconometrics, and one semester of macroeconomic theory. Students also take the AAEC 5004 seminar course in professional ethics and expectations their first Fall semester and AAEC 6004 Seminar in Professional Engagement and Communication in Spring of their second year. Beginning in the second year of the program, Ph.D. students are required to complete two field courses in each of their two fields, and at least one elective course that supports their fields and areas of research specialization. Beyond the core coursework requirements, individual programs of study are determined jointly by the student and his/her advisory committee chair. Students who are admitted to the Ph.D. program without having completed a master's degree at another institution often earn an M.S. at Virginia Tech as part of their Ph.D. program. The credit hours applied to the master's degree can also be counted toward the Ph.D. coursework requirements. A similar rule applies for students who are initially in a master's degree program and are subsequently admitted to the Ph.D. program. In addition to coursework, Ph.D. students are required to pass three examinations: (1) a written qualifying examination, (2) a written and oral preliminary examination, and (3) a final oral dissertation defense. More information on these requirements is available at the Department's Graduate Program website.

GRADUATE COURSES (AAEC)

AAEC 5004:

Seminar

Formal presentation and discussion of current problems, programs, and

research studies in agricultural economics. Presentations and discussions. Repeatable for credit.

Credit Hour(s): 1

Lecture Hour(s): 1

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

AAEC 5024:

Mathematical Programming for Economist

Employing economic principles to optimally achieve the goals of firms as a whole. Linear, non-linear, and integer programming are employed to model firm decision making.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): AAEC 3004 (UG) OR AAEC 3004 OR ECON 3104 (UG) OR ECON 3104

Corequisite(s):

AAEC 5025:

Applied Microeconomic

Basic economic theory of food and fiber production, food and fiber consumption, agricultural markets, and social welfare as influenced by the agricultural sector. Major emphasis placed on application of theory to current agricultural and resource problems.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): (MATH 1526 (UG) OR MATH 1526, ECON 3004 (UG) OR ECON 3004) OR (ECON 3104 (UG) OR ECON 3104)

Corequisite(s):

AAEC 5026:

Applied Microeconomics

Basic economic theory of food and fiber production, food and fiber consumption, agricultural markets, and social welfare as influenced by the agricultural sector. Major emphasis placed on application of theory to current agricultural and resource problems.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): (MATH 1526 (UG) OR MATH 1526, ECON 3004 (UG)

OR ECON 3004, ECON 3104 (UG) OR ECON 3104)

Corequisite(s):

AAEC 5034:

Agribusiness Marketing

Marketing tools needed to identify and solve the complexity of marketing food and agribusiness products. Contemporary trends, marketing strategies, and problems in the food and agribusiness sector. Pre: Understanding of introductory microeconomic theory. Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

AAEC 5104:

Research Project Plan

Planning and executing a research project with emphasis on problem identification, formulation of hypothesis, choice of appropriate empirical technique and data sources.

Credit Hour(s): 1

Lecture Hour(s): 1

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

AAEC 5114:

Applied Microeconomic Theory

Theoretical and empirical issues in developing and implementing microeconomic models. Topics include duality, risk, household production, selecting functional forms, aggregation, and numerical partial and general equilibrium models.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECON 5006, (AAEC 5126 OR ECON 5126)

Corequisite(s):

AAEC 5125 (ECON 5125):

Empirical Research Methods in Economics

Extensive treatment of new techniques for economic modeling. 5125: Probability and statistical inference, linear regression and related dynamic models, specification, estimation, misspecification,

respecification, identification. 5126: Simultaneous equations, dynamic systems, time series, limited dependent variable models. Permission of the Director of the Graduate Studies required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

AAEC 5126 (ECON 5126):

Empirical Research Methods in Economics

Extensive treatment of new techniques for economic modeling. 5125: Probability and statistical inference, linear regression and related dynamic models, specification, estimation, misspecification, respecification, identification. 5126: Simultaneous equations, dynamic systems, time series, limited dependent variable models. Permission of the Director of Graduate Studies required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): AAEC 5125 (UG) OR AAEC 5125

Corequisite(s):

AAEC 5134:

Agricultural Marketing

Concepts of technical and economic efficiency as they are related to the flow of agricultural products from farm to consumer. Major topics include: market equilibrium over time, space and form; price discovery under different market structures, and price risk management with futures and options.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECON 3104 (UG) OR ECON 3104

Corequisite(s):

AAEC 5144:

Resource and Environmental Economics

Economic theory and methods are applied to analysis of the uses of natural resources, environmental problems and public investment planning. The contribution of economic analysis to public policy formulation is stressed.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECON 3104 (UG) OR ECON 3104 OR AAEC 3004 (UG) OR AAEC 3004

Corequisite(s):

AAEC 5154:

International Agricultural Development and Trade

This course focuses on the role of agriculture in economic development and the effects of alternative trade policies and practices in less developed nations. Topics include agriculture in theories of development, population growth, migration, the economic organization of the peasant-household firm, technological change, institutional change, effects of trade restrictions, exchange rates, trade preferences, regional economic groupings, food aid, trade negotiations, agricultural sector marketing, and project analysis.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECON 3104 (UG) OR ECON 3104

Corequisite(s):

AAEC 5174:

International Agricultural Development and Trade

Agriculture in world economic development, agricultural modernization strategies, and the effects of trade policies and agreements on agriculture. Dimensions of world food, population, income, and natural resource issues; technological and institutional change; trade, capital flows, and foreign aid. Pre: Understanding of introductory microeconomic and macroeconomic theory. Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

AAEC 5244:

Rural Development

Theory and methods related to economic development of rural America. Considers the roles of agriculture, resources, human capital, and federal, state and local governments in development processes. Outlines the constraints created by resource scarcity, location and government policy. Quantitative methods in resource development, regional development and impact analysis are introduced.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

AAEC 5484 (STAT 5484):

Applied Economic Forecasting

Forecasting economic, agricultural and environmental data using basic linear and non-linear time series models. Emphasis on programming and computational implementation of time series model-selection techniques and practical applications. Pre: Graduate Standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

AAEC 5804G:

Fundamentals of Econometrics

Introduction to economic applications of mathematical and statistical techniques: regression, estimators, hypothesis testing, lagged variables, discrete variables, violations of assumptions, simultaneous equations, instrumental variables, panel data methods. Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

AAEC 5814G:

Adv Food & Health Economics

Microeconomics of food, nutrition, and health. Overview of nutrition, nutrition recommendations, and implications for economic based decisions. Individual and household food consumption and health production models. Farm to consumer market linkage models with nutrition and health implications. Effectiveness of food and nutrition interventions and policies. Cost-benefit and cost-effectiveness analysis of health interventions. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

AAEC 5894:**Final Examination**

NONE

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

AAEC 5904:**Project and Report**

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research, Online Research

Instruction Type(s): Research, Online Research

Prerequisite(s):

Corequisite(s):

AAEC 5946 (ECON 5946):**Econometric Theory and Practice**

An intensive coverage of the most important techniques of econometric estimation and hypothesis testing, addressing the use of both cross-section and time series data, A core sequence in the MA program in both locations. Prerequisite to the research-thesis seminar in Northern Virginia. I,II

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): AAEC 5126 OR ECON 5126

Corequisite(s):

AAEC 5954:**Study Abroad**

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

AAEC 5974:**Independent Study**

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Independent Study

Instruction Type(s): Independent Study

Prerequisite(s):

Corequisite(s):

AAEC 5984:**Special Study**

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

AAEC 5994:**Research and Thesis**

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research

Instruction Type(s): Research

Prerequisite(s):

Corequisite(s):

AAEC 6004:**Seminar**

Formal presentation and discussion of current problems, programs, and research studies in agricultural economics including projects employing advanced theoretical and quantitative techniques. Presentations and discussions. Repeatable for credit, up to 3 (M.S.) or 4 (Ph.D.) times.

Credit Hour(s): 1

Lecture Hour(s): 1

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

AAEC 6214:**Food and Health Microeconomics**

Microeconomics of food and health. Overview of nutrition

recommendations and implications for economic decisions. Individual

consumer market linkage models with nutrition and health implications.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): AAEC 5126, ECON 5006, ECON 5016, ECON 5124

Corequisite(s):

AAEC 6224:

Food & Health Macro Economics

Introduction to policy and intervention design and evaluation, including review of basic nutrition, contract theory and applications, intervention outcome metrics, nonmarket evaluation, empirical cost effectiveness analysis and treatment effect estimations.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECON 5006, (ECON 5126 OR AAEC 5126)

Corequisite(s):

AAEC 6304:

International Trade and Finance

Core models in international trade and finance; current topics in international economics. Ricardian, Heckscher-Ohlin-Samuelson, Dynamic imperfect competition trade theories; Political economy of trade; Trade policy, Factor mobility, Uncertainty, and Intra-industry trade. Mundell-Fleming, Monetary, Real- and Imperfect competition- Micro-foundations theories of international macroeconomics; exchange rate determination; and capital markets. Extensions to monetary and fiscal policy, economic growth, and external debt analysis.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECON 5005, ECON 5015

Corequisite(s):

AAEC 6314:

Topics Applied Dev Econ

Economic theories and empirical methods for measuring poverty, inequality, and vulnerability, and for targeting social programs. Topics include theory of the farm household and empirical methods to measure effects of public policies, interactions between the environment and development policy, methods for measuring technical change and its impacts, effect of social networks on technology adoption, and the role of microfinance in economic development.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECON 5006, ECON 5126

Corequisite(s):

AAEC 6444:

Regional and Urban Economics

An advanced study of the theory and application of regional and urban economics, with particular focus on the spatial aspects of economic activity. Topics include: nature of regional and urban areas, models of regional economies, location choice of firms and consumers, local public finance, housing, transportation, and labor markets.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECON 5005 (UG) OR ECON 5005, (ECON 5126 (UG)

OR ECON 5126 OR AAEC 5126 (UG) OR AAEC 5126)

Corequisite(s):

AAEC 6524:

Env Theory & Policy Analysis

Advanced coverage of the theory of environmental economics and policy. Topics covered in the course include: theory of externalities and public goods, theory behind policy instruments, issues with non-point source and transboundary pollution, and the role of the political economy for environmental problems.

Credit Hour(s): 4

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ECON 5006

Corequisite(s):

AAEC 6554 (ECON 6554):

Panel Data Econometrics

Introduction to major panel data techniques and modeling ideas currently employed (e.g., dynamic panel, panel for discrete choice model, treatment effect and program evaluations etc.), including both statistical theory derivations and practical applications.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

492 Prerequisite(s): (AAEC 5124 OR ECON 5124), AAEC 5126

Corequisite(s):

AAEC 6564 (STAT 6564) (ECON 6564):

Bayesian Econometric Analysis

Bayesian estimation of economic models, with focus on Gibbs sampling, hierarchical modeling, data augmentation, and model search. Strong emphasis on programming and computational implementation.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): AAEC 5126 OR ECON 5126 OR STAT 5304 OR STAT 5444

Corequisite(s):

AAEC 6984:

Special Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

AAEC 7994:

Research and Dissertation

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research

Instruction Type(s): Research

Prerequisite(s):

Corequisite(s):

AGRICULTURE, LEADERSHIP, AND COMMUNITY EDUCATION

Tracy Rutherford, Head

Professors: Loy Crowder; Eric Kaufman; Rickie Rudd; Tracy Rutherford;

Associate Professors: Thomas Archibald; Curtis Friedel; Kimberly Niewolny; Donna Westfall-Rudd;

Assistant Professors: Kellie Clafin; Austin Council; Tiffany Drape; Richard Rateau; Hannah Scherer; Megan Seibel; Karen Vines; Jerald Walz;

Adjunct Professors: Jennifer Culhane; Makane Kane; Steven Manchester; Ya

Cor Ndione;

Community Viability Chair of Excellence: Rickie Rudd;

Graduate Site: <https://www.alce.vt.edu/student-info/graduate.html>

The Department of Agricultural, Leadership, and Community Education (ALCE) is nationally recognized as a comprehensive program encompassing teaching and learning, extension, community development and education and leadership in agriculture. We are social scientists practicing in the context of agriculture and life science. Our research, teaching, and extension programs enhance and strengthen the people engaged in agriculture life sciences. Graduate studies in ALCE are grounded in our programmatic research in problem solving, leadership development, critical thinking, program development and evaluation, secondary education, non-formal education, and professional development. These research areas form our concentration areas of teaching and learning, leadership & social change and community education and development.

SPECIAL FACILITIES

Virginia Tech's Department of Agricultural, Leadership, and Community Education is located in Litton-Reaves Hall. In addition, we work with county extension offices and secondary schools across the state.

Litton-Reaves Hall

The main office for ALCE is located in 214 Litton-Reaves Hall. Faculty offices are also located in Litton-Reaves.

DEGREES OFFERED

MS Degree

Offered In (Blacksburg, Virtual)

TOEFL

Paper: (550.0)

Computer: (213.0)

iBT: (80.0)

The department offers a M.S degree and partners in two other M.S. degree programs. The department offers a M.S. in Life Sciences with an emphasis in Agricultural Education (MS). We are a partner in the College of Agriculture and Life Sciences for the ALS (MS) degree. In addition, we are a partner with the Virginia Tech School of Education in offering an M.S. degree for agriculture teacher certification MSED/EDCT. MSLF/AEEThe Master of Life Sciences requires students to complete a thesis and final examination. A considerable amount of time is spent conducting research and writing. This degree is intended for students who plan to pursue a Ph.D. in teaching and learning, community education and development, or leadership and social change. OMALS (Education Concentration or Leadership Studies Concentration)The Master of Agricultural and Life Science is a non-thesis degree intended for practicing professionals in education, extension or other forms of community development work. This degree is delivered by distance to students who are place-bound. Although this degree is intended for students who do not wish to pursue a doctoral degree, it does not eliminate students from that academic option if chosen in the future.

Each student will complete a final project that adds to the knowledge base of best practices in our profession. The project defense (final examination) will be held at the end of a student's program.

MSED/EDCTThe Master of Science in Career and Technical Education is offered on the Virginia Tech campus for students seeking certification in teaching secondary agricultural education. This program is housed in the School of Education and delivered in partnership with ALCE.

Students who complete the program receive a degree from the School of Education. This is a non-thesis degree. Students are required to pass a comprehensive examination to complete the program.

PhD Degree

Offered In (Blacksburg)

TOEFL

Paper: (550.0)

Computer: (233.0)

iBT: (90.0)

The Ph.D. in Life Sciences with an emphasis in Agricultural Education (PHD) is intended for students who desire to be faculty in universities delivering comprehensive programs in agricultural, leadership, and community education. Our program focus allows us to deliver a customized program for students preparing for the Professoriate. Courses, experiences, and research are all focused on providing a solid foundation for future faculty who will be initially competitive and highly productive throughout their career. Our Ph.D. program provides a solid background in research and students are expected to produce unique discoveries in teaching and learning, community education and development, and leadership & social change. Students are expected to publish and present in the program as well as assist in securing funded projects. Faculty members work with students to meet individual educational goals. Our faculty are known for strong advisement and personal attention for each student. Students are provided with opportunities to teach in formal classrooms and non-formal settings, conduct meaningful research, and deliver outreach programs. The degree requires a comprehensive examination to enter Ph.D. candidacy. The comprehensive exam and oral defense is an opportunity for a student to showcase their abilities in the areas of integrating and synthesizing information relevant to their program. Advisor and committee member roles at this stage include 1) providing support and encouragement, 2) providing collegial and constructive dialogue, 3) creating an environment where ideas are shared in a professional environment free of condescension, derision and hostility, 4) providing feedback in a timely manner and 5) completing their tasks with all relevant signatures or other paperwork. Each student will complete a dissertation that adds to the knowledge base of our profession. The dissertation defense (final examination) will be held at the end of a student's program.

GRADUATE COURSES (ALCE)

ALCE 5004:

Teaching Practice Ag Life Sci

Preparation of critically reflective and skillful college teachers in agriculture and life sciences. Theories, principles and practices associated with effective teaching in higher education. Understanding

and development of skills and abilities related to teaching and learning.

Pre: Graduate standing.

Credit Hour(s): 1

Lecture Hour(s): 1

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ALCE 5014:

Non-Formal Teaching & Learning: Principles & Methods

Principles and methods associated with non-formal teaching and learning for community and extension education as well as secondary educational settings such as agricultural education. Concepts and practical knowledge for designing, integrating, and justifying non-formal educational experiences for learners. Learning frameworks and approaches that emphasize the role of participation, facilitation, and other student-centered teaching and learning approaches in agriculture and life science professions. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ALCE 5024:

Supervised Experience Programs in Agriculture

Designed to provide information and assistance for developing and conducting a supervised occupational experience program. Includes identification of principles and trends in occupational experience programs, procedures in conducting an occupational experience program, and evaluation of experience programs.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ALCE 5034:

Teaching Agric Mechanics

The coordination of essential elements required for an effective agricultural mechanics program. Special emphasis placed upon integration agricultural mechanics instruction into a local agricultural education program, liability, curriculum content selection, special teaching methodologies and student assessment.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ALCE 5044:

Program and Curriculum Design in Agricultural and Extension Education

Methods involved in the organization, management, and evaluation of programs and curricula for agricultural education and cooperative extension.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ALCE 5054:

STEM Integration in Agricultural Education

Contemporary methods, strategies, and justification for incorporation of science, technology, engineering and mathematics (STEM) concepts and practices into secondary agricultural education programs. Use of best practices for STEM teaching and learning and enhancement of STEM content in existing agriculture courses. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ALCE 5074:

Foundations of Agricultural, Leadership, and Community Education

The history and current state of agricultural education and extension, leadership, and community viability. Current issues in agriculture, leadership, and community education as they relate to agriculture education and extension domestically. Pre: Graduate Standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ALCE 5104:

Research Applications in Agricultural and Extension Education

Professional applications of research from the perspective of the research consumer rather than the researcher. Locating, accessing, interpreting, evaluating, applying, and communicating the results of research to the lay public in agricultural and extension education settings. Emphasis on professional and scientific research published in agricultural, applied life sciences, agricultural education, and cooperative extension outlets.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ALCE 5114:

Serving Intl Ag & Education

International agricultural and outreach education in both developed and developing countries. Skills formal and non-formal educators need in an international setting. Especially for educators and leaders in agriculture and Cooperative Extension. Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ALCE 5154:

Partnerships and Volunteerism

Students will develop competencies in the development and direction of community volunteer partnerships and collaborations. Students will explore current volunteer development models, collaboration process theory, and key management areas including: visioning, organizing a partnership or collaboration; creating motivating volunteer positions; recruiting, screening, and interviewing; orientation and training; supervising; evaluation; retention and resolution; risk management, and measuring program effectiveness.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

Evaluation of Extension and Outreach Programs

Theory and practice of program evaluation in community education settings such as extension and outreach programs. Evaluation concepts and methods to plan and execute well-constructed program evaluations.

Major traditions, current controversies, and new directions in evaluation.

Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ALCE 5224:

Team Science, Cooperation, and Interdisciplinary Work

Theoretical and conceptual basis for thinking about, guiding, and supporting team science and cooperative processes for interdisciplinary research, programming, and outreach. Current scholarship and concepts of individual and team readiness, effectiveness, protocols, training, and outcomes in team science and cooperative process contexts. Pre:

Graduate Standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ALCE 5304G:

Community Education and Development

Comprehensive examination of community education and development.

Community/sustainable community development, strategies for mobilizing social change in/with communities. Explore participatory, popular, and community-based education from rural and urban settings.

Globalization, sustainability, and social movement discourses with emphasis on agricultural, health, and food system examples. Pre:

Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ALCE 5564:

International Agriculture & Diplomacy

Advanced study on agricultural leadership. U.S. geostrategic context that

includes history, geography, natural resources, cultural identity, governance, macro-economic policy, and security interests shaping the U.S. and international agricultural foreign policies. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ALCE 5614:

Politics and Practice of Food Security and Social Justice

Interdisciplinary and intersectional exploration of current issues related to the politics and practice of food security. Concepts of community food security, food sovereignty, food justice, and agricultural sustainability from local, regional, and international perspectives. Empirical examples and conceptual frameworks to address health equity, community resiliency, and food system social justice. Regional storytelling research project with food and farming practitioners. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ALCE 5704:

Systems Thinking Pedagogy and Praxis

Strategies promoting systems thinking in formal and non-formal educational and community contexts. Instructional design for developing systems thinkers. Systems approaches to understanding problematic situations and creating change using agricultural, community-based, and extension education examples. Foundational complex systems concepts and systems thinking perspectives for social and socio-ecological systems. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ALCE 5754:

Internship in Ag&Extension Ed

Student participation in a planned clinical experience under supervision of a university faculty member in an approved, appropriate professional

setting. A written Internship Agreement must be completed and approved before the internship begins.

Credit Hour(s): 1 TO 12

Lecture Hour(s): 1 TO 12

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ALCE 5764:

Externship in ALCE

Students participate in a special interdisciplinary problem-solving approach for experienced agricultural education and extension professionals who are engaged in part-time graduate study while continuing in positions of leadership. Interdisciplinary teams of faculty work with small groups of experienced professionals in systematic analysis of contemporary issues. Students are judged on quality of their investigations, individual reports, and delivery of subject matter.

(Maximum 12C). Consent required.

Credit Hour(s): 1 TO 12

Lecture Hour(s): 1 TO 12

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ALCE 5904:

Project and Report

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Research, Online Research

Instruction Type(s): Research, Online Research

Prerequisite(s):

Corequisite(s):

ALCE 5954:

Study Abroad

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ALCE 5964:

Field Study

NONE

Credit Hour(s): 1 TO 12

Lecture Hour(s): 1 TO 12

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ALCE 5974:

Independent Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Independent Study, VI

Instruction Type(s): Independent Study, VI

Prerequisite(s):

Corequisite(s):

ALCE 5984:

Special Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ALCE 5994:

Research and Thesis

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Research, Online Research

Instruction Type(s): Research, Online Research

Prerequisite(s):

Corequisite(s):

ALCE 6014:

Theoretical Foundations of Non-Formal Learning

Overview of the theory and practice of non-formal learning emerging paradigms, and historical debates. Development of specific pedagogies based on non-formal learning theories. Education settings and issues relevant to agricultural and extension educators including extension education, community-based education, agriculture training and

movements/social activism. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ALCE 6234:

Theory & Practice of Community-Based Participatory Research

The theory and practice of Community-based Participatory Research (CBPR). Empirical examples from community development, agriculture and food systems, community health, and human nutrition. Principles of CBPR, practical and ethical issues in collaborating with communities, participatory action methods, and approaches to evaluation. Pre:

Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ALCE 6415:

Introduction to Graduate Teaching Scholars (GTS)

6415: Theories of learning for instruction of college-level agricultural and life sciences courses. Student-centered teaching strategies. Student assessments based on classroom observations. Pre: Graduate Standing. 6416: Strategies for college-level agricultural and life sciences course instructional design. Postsecondary teaching. Pedagogy using classroom observations, specialized topics in teaching, and experience with mentors to develop individual teaching skills and pedagogy. Pre: Graduate Standing.

Credit Hour(s): 2

Lecture Hour(s): 1

Instruction Type(s): Lab, Lecture, VB, Online Lecture

Instruction Type(s): Lab, Lecture, VB, Online Lecture

Prerequisite(s):

Corequisite(s):

ALCE 6416:

Introduction to Graduate Teaching Scholars (GTS)

Strategies for college-level agricultural and life sciences course instructional design. Postsecondary teaching. Pedagogy using classroom observations, specialized topics in teaching, and experience with mentors to develop individual teaching skills and pedagogy.

Credit Hour(s): 2

Lecture Hour(s): 1

Instruction Type(s): Lab, Lecture, VB, Online Lecture

Instruction Type(s): Lab, Lecture, VB, Online Lecture

Prerequisite(s): ALCE 6415

Corequisite(s):

ALCE 6425:

University Teaching Development (GTS)

6425: Guided experiences in planning and teaching courses at the university level. Utilize the first year experiences to develop skills and practice in lesson planning, course management, and advanced teaching strategies. Work with faculty mentors to plan and organize teaching materials. 6426: Continued development of teaching knowledge and skills appropriate for contemporary secondary classrooms. Examination of effective classroom management strategies and resources for continued development of professional teaching practice. Implement teaching skills and knowledge co-teaching course assigned in the program.

Credit Hour(s): 2

Lecture Hour(s): 1

Instruction Type(s): Lab, Lecture, VB, Online Lecture

Instruction Type(s): Lab, Lecture, VB, Online Lecture

Prerequisite(s): ALCE 6416

Corequisite(s):

ALCE 6426:

University Teaching Development (GTS)

Continued development of teaching knowledge and skills appropriate for contemporary postsecondary classrooms. Examination of effective classroom management strategies and resources for continued development of professional teaching practice. Implement teaching skills and knowledge co-teaching course assigned in the program.

Credit Hour(s): 2

Lecture Hour(s): 1

Instruction Type(s): Lab, Lecture, VB, Online Lecture

Instruction Type(s): Lab, Lecture, VB, Online Lecture

Prerequisite(s): ALCE 6425

Corequisite(s):

ALCE 6435:

Engagement in University Teaching (GTS)

6435: Preparation for faculty with teaching related responsibilities. Advising and mentoring undergraduate students, developing effective student assessments, and application of contemporary student centered teaching methods in college classrooms. 6436: Pursue postsecondary faculty positions with teaching appointments. Preparation for the first

observations and feedback, finding innovative teaching resources at different universities, mentoring graduate students, and engaging in scholarship of teaching and learning.

Credit Hour(s): 3

Lecture Hour(s): 1

Instruction Type(s): Lab, Lecture, VB, Online Lecture

Instruction Type(s): Lab, Lecture, VB, Online Lecture

Prerequisite(s): ALCE 6416

Corequisite(s):

ALCE 6436:

Engagement in University Teaching (GTS)

6435: Preparation for faculty with teaching related responsibilities.

Advising and mentoring undergraduate students, developing effective student assessments, and application of contemporary student centered teaching methods in college classrooms. 6436: Pursue postsecondary faculty positions with teaching appointments. Preparation for the first year of postsecondary teaching including managing effective peer observations and feedback, finding innovative teaching resources at different universities, mentoring graduate students, and engaging in scholarship of teaching and learning.

Credit Hour(s): 3

Lecture Hour(s): 1

Instruction Type(s): Lab, Lecture, VB, Online Lecture

Instruction Type(s): Lab, Lecture, VB, Online Lecture

Prerequisite(s): ALCE 6435

Corequisite(s):

ALCE 6984:

Special Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ALCE 7964:

Field Studies

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ALCE 7994:

Research and Dissertation

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Research, Online Research

Instruction Type(s): Research, Online Research

Prerequisite(s):

Corequisite(s):

AGRICULTURAL AND LIFE SCIENCES

Professors: Renee Boyer; Walter Daniels; Douglas Pfeiffer; Kerry Redican; Rickie Rudd; Elena Serrano; Susan Sumner; Gregory Welbaum; Anthony Wolf; Kang Xia;

Associate Professors: Antonius Baudoin; Alan Ealy; Matthew Eick; Joseph Eifert; John Galbraith; William Hession; Eric Kaufman; Sally Paulson; Donna Westfall-Rudd; James Westwood;

Assistant Professors: Angela Anderson; Thomas Archibald; Tiffany Drape; Curtis Friedel; Madlyn Frisard; Vitor Mercadante; Carlin Rafie; Richard Rateau; Hannah Scherer; Roger Schuerch; Karen Vines; Robert Williams;

Affiliated Faculty: Azenegashe Abaye; Kristen Chang; Dixie Dalton; Jennifer Jones; Joshua Kardos; Megan Seibel; Jennifer Zabinsky;

Assistant Professor of Practice: Michelle Rockwell;

General Contact: jejone18@vt.edu

Academic Progress: jejone18@vt.edu

Graduate Site: <http://www.cals.vt.edu/online/index.html>

This master's degree program has been designed for potential students who are place bound, but would still like to pursue a rigorous graduate-level degree. Courses and the final project are arranged to meet the goals of the student. The student selects one of six concentration areas on which to focus: (1) Applied Nutrition and Physical Activity; (2) Education; (3) Environmental Science; (4) Food Safety and Biosecurity; (5) Leadership Studies; and (6) Plant Science and Pest Management. In addition to course work in the chosen Concentration Area, courses are required from a Core Curriculum and a final project and report is required.

SPECIAL FACILITIES

This degree program offers flexibility in that most courses are offered asynchronously, allowing work to be completed during a time that is convenient for the individual student. Students must have access to a computer and online resources. High speed access is highly recommended; some course materials may not work smoothly with slower dial up systems.

The program is completely web-based and allows students to successfully earn the degree without visiting the Blacksburg campus.

DEGREES OFFERED

MS Degree

Offered In (Virtual)

TOEFL

Paper: (550.0)

Computer: (213.0)

iBT: (80.0)

The student designs a program of at least 30 credits. Seven credits must include courses in the core, including one credit hour of ALS 5904. Each student selects 12 credit hours from their selected concentration area. Six credit hours are selected as electives, generally from another concentration. Five credit hours are taken in the form of research hours within the concentration area, culminating in a final scholarly report.

Degree Concentrations:

Applied Nutrition and Physical Activity

The Applied Nutrition and Physical Activity concentration is designed for students with a science, health-related, community, or education background who wish to advance and expand their nutrition and physical activity knowledge and skills. Courses offer an evidence-based perspective on applied nutrition and exercise across the healthspan. A focus on critical inquiry, problem solving, leadership, and successful business practices in nutrition and physical activity is carried throughout. Upon completion of the OMALS degree with a concentration in Applied Nutrition and Physical Activity each student will be able to: Demonstrate a foundational understanding of nutrition and physical activity sciences and their application to health promotion. Demonstrate an in-depth knowledge in applied nutrition, physical activity, or public health policy as dictated by the student's area of specialization. Apply research methods in nutrition, physical activity, or public health to design, implement, and evaluate projects or programs. Apply nutritional, exercise, or public health policy practices to assess and implement best practice interventions for health and well-being. Communicate nutrition, exercise, or public health messages across diverse audiences.

Education

Increasingly, individuals within the agricultural and life sciences are asked to train others on new techniques or equipment, develop programming that engages the public, or communicate new concepts in a variety of different settings to a diverse group of people. The Education concentration is designed for individuals desiring to advance their teaching/learning, leadership, extension and communications skill sets in this dynamic and evolving field. This in-depth program will provide concrete strategies for assisting individuals and communities with diverse needs and interests, and providing them with the abilities to

acquire and retain the information shared, including youth and adult program management, program curriculum design, STEM integration in agriculture education, and service to international service and partnerships. This program is designed to advance your position as an agricultural leader, educator, and communicator. Upon completion of the OMALS degree with a concentration in Education each student will be able: Examine the scholarly literature and illustrate connections to the practice of teaching and learning Design, implement and evaluate educational curriculum, programming and outreach in agricultural and life sciences Integrate research based agricultural, leadership, and community educational models into practice Perform and evaluate research applications in agricultural, leadership, and community education Evaluate the use of technology in agricultural, leadership, and community education curriculum

Environmental Sciences

The Environmental Science concentration will provide students with the knowledge and skills to solve real-world environmental issues. As a student in this program, you will interact with faculty and professionals in the field. Working through hands-on activities you will gain a greater understanding of environmental science theory and practical application. This tailored educational experience will position you to effectively and strategically lead in this field. Upon completion of the OMALS degree with a concentration in Environmental Science each student will be able: Demonstrate breadth and depth of interdisciplinary knowledge related to complex environmental issues and processes. Design, implement, and evaluate an assessment and mitigation plan for diverse at-risk ecosystems. Apply a variety of regulatory practices, standards, or policies related to water and soil quality and use. Identify, analyze, and evaluate evidence-based literature and practice related to water and soil quality. Apply research methods to design, implement, and evaluate sustainable approaches of environmental management for a variety of at risk ecosystems.

Food Safety and Biosecurity

The Food Safety and Biosecurity concentration will build on a student's knowledge of food safety, security, sanitation, and microbiology. It is designed for individuals interested in the microbiological safety of food, water and the environment, including the development and enforcement of laws and regulations affecting food production and processing, the implementation of food safety management programs, and the biosecurity of food supplies in developing countries. Upon completion of the OMALS program with a concentration in Food Safety and Biosecurity each student will be able to: Demonstrate breadth and depth of knowledge of evidence-based food safety and food biosecurity practices. Apply scientific literature to critically evaluate the practices of legal and regulatory issues on food safety and food biosecurity Demonstrate in-depth knowledge of fundamental concepts relevant to food safety and food biosecurity practices across diverse agriculture scales (local, state,

national, and global). Design, implement, and evaluate food safety and food biosecurity management programs and practices. Identify sources of food safety and food biosecurity information and distinguish reliable sources from unreliable sources.

Leadership Studies

The Leadership Studies concentration prepares individuals with interdisciplinary skills to be well-rounded agricultural professionals, developing leaders, educators, and communicators to lead, teach and communicate about current agricultural issues facing society today. Students will gain the expertise necessary to lead in a diverse and multicultural environment. Programmatic emphasis is placed on leadership in a global society, problem-solving, and the role of agricultural professionals as agents of change in our communities throughout the world. Upon completion of the OMALS degree with a concentration in Leadership Studies each student will be able to: Demonstrate leadership for effective problem solving with groups, organizations, and communities. Critically analyze leadership theory and practices through scholarly inquiry. Examine social responsibility in diverse and multicultural environments. Design, implement, and evaluate collaborative leadership efforts in real-world settings.

Plant Science and Pest Management

The Plant Science and Pest Management concentration will prepare students in agriculture-related roles to have a broader understanding of the diverse industry, including issues concerning production, business, economics, communication, pest management, and regulations. Students will gain a sophisticated understanding of this interdisciplinary field with specialized skills in areas such as weed science, plant pathology, and crop management. Upon completion of the OMALS degree with a concentration in Plant Science and Pest Management each student will be able to: Demonstrate in-depth multidisciplinary knowledge of fundamental concepts relevant to plant science and pest management practices across diverse agriculture scales (local, state, national, and global). Examine and apply the evidence-based literature to resolve relevant complex plant science and pest management issues within multiple agricultural sectors. Design, implement, and evaluate plant science and pest management programs and practices across diverse scales of agriculture. Analyze the research applications/models/procedures to demonstrate interconnections between plant science, pest management, and human ecology, and animal health. Apply multimedia strategies to communicate topics and concepts that enhance plant science and pest management practices in diverse communities and scales of agriculture.

GRADUATE COURSES (ALS)

ALS 5034:

Mathematical Modeling of Metabolic Systems

Techniques used to model nutrient metabolism and associated cellular and systemic responses including compartmental analyses, numerical integration, sensitivity analyses, and parameter estimation. Interpretation and extension of experimental data including isotopic tracers. Prediction of biological responses to nutrient inputs. Pre: Graduate Standing

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ALS 5064 (BIOL 5064) (BCHM 5064):

Seminar in Molecular Cell Biology and Biotechnology

Review and discussion of current problems and literature in molecular cell biology and biotechnology by students, VPI&SU faculty and outside speakers. Students give formal presentations of research results or current literature. May be taken on pass-fail basis. Students enrolled in the MCBB Ph.D. option will be required to give one formal presentation on an A-F basis. Graduate status in participating MCBB departments required.

Credit Hour(s): 1

Lecture Hour(s): 1

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ALS 5084:

Advanced Ruminant Nutrition Colloquium

Research papers in nutrition of ruminant animals (beef, dairy, sheep) will be reviewed. Research papers will be selected from scientific journals such as the Journal of Dairy Science, the Journal of Animal Science, the Journal of Nutrition, and Animal Feed Science and Technology. May be repeated (no restriction on number of times). Graduate standing required.

Credit Hour(s): 1

Lecture Hour(s): 1

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ALS 5094:

Effective Grant Writing for the Biomedical and Behavioral Sciences

The grant writing process and developing student skills for successful grant writing to support research enterprises. Students will prepare a mock research grant proposal for obtaining funds from the National Institutes of Health, National Science Foundation, or the US Department of Agriculture and participate in panel review of grant proposals of peers.

Credit Hour(s): 1

Lecture Hour(s): 1

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): APSC 5004 OR (ALS 5064 OR BIOL 5064 OR BCHM 5064 OR PPWS 5064)

Corequisite(s):

ALS 5104:

Communicating Research and Leadership in Agriculture and Life Sciences

Principles and strategies for effective leadership and communication in agricultural and life sciences (ALS). Analysis, synthesis and translation of research information for use in practical settings. Effective ALS knowledge. Evaluation of research design and methodology in action research. Pre: Graduate standing.

Credit Hour(s): 2

Lecture Hour(s): 2

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

ALS 5115:

Nutrition

Digestion, absorption and metabolism of nutrients in animals including humans. 5115: Digestive physiology; digestion and absorption; bioenergetics; and carbohydrate and lipid metabolism with emphasis on substrate sources, interrelationships, and factors affecting utilization and metabolism. Graduate Standing required. 5116: Absorption, metabolism and function with emphasis on physiological and biochemical aspects of protein, amino acid, vitamins, and minerals; epidemiological, biochemical, cellular or molecular methodologies useful for study of macronutrients and micronutrients and their biological functions also will be covered.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ALS 5116:

Nutrition

Digestion, absorption and metabolism of nutrients in animals including humans. 5115: Digestive physiology; digestion and absorption; bioenergetics; and carbohydrate and lipid metabolism with emphasis on substrate sources, interrelationships, and factors affecting utilization and metabolism. Graduate Standing required. 5116: Absorption, metabolism and function with emphasis on physiological and biochemical aspects of protein, amino acid, vitamins, and minerals; epidemiological, biochemical, cellular or molecular methodologies useful for study of macronutrients and micronutrients and their biological functions also will be covered.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ALS 5115

Corequisite(s):

ALS 5134:

Community-Based Applications of Qualitative Inquiry

Community-based applications of qualitative inquiry in Agricultural and Life Sciences. Qualitative methodology in community-based research with a focus on ethics and inclusivity. Interviews and focus groups. Professional best practices and enhance communication. Best practices for a community approach, interview facilitation, and reporting for professional audiences. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

ALS 5204:

Research and Information Systems in the Life Sciences

A focus on research techniques and processes for life science professions. Topics include: history of applied life sciences, current structure of the scientific enterprise, the scientific method and quality assurances, researching the literature, scientific writing and presentation of research results, instructional techniques, professionalism, and ethical considerations. Information technology is employed throughout the course. Students learn to use digital technologies for communication, presentation, and publication.

Credit Hour(s): 0 OR 3

Lecture Hour(s): 0 OR 1

Instruction Type(s): Lab, Lecture, Online Lecture

Instruction Type(s): Lab, Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ALS 5214:

Information Systems and Research in the Life Sciences

Research techniques and processes used in the life science professions.

History of applied life sciences, structure of the scientific enterprise, the scientific method and quality assurances, researching the literature and critically evaluating information, scientific writing and communication of research results, professionalism, and ethics. Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ALS 5224:

Introduction to Genomic Data Science

Analysis of genomic data for applications in agriculture and life sciences.

Computational tools for genomic data processing and quality control.

Interpret results from genomic experiments. Summary statistics, machine learning and methods of visualization for genomic data. High Performance Computing (HPC) systems for genomic analysis. Genomic data analysis pipelines. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ALS 5234G:

Adv Concepts Comm Food Systems

Examination of the economic, political, social, and cultural issues related to community food systems and agricultural practices. Topics include local and regional food systems development, food production and biotechnology, food sovereignty and security, and population and environmental health. Analysis of models, strategies, and policies of national food systems. Pre-requisite: Graduate Standing required

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ALS 5304:

Advanced Physiology and Anatomy of Domestic Animals

Mammalian physiology and anatomy will be evaluated in domestic animals, laboratory animals, and primates. Emphasis will be on the cardiovascular, renal, respiratory, neural, muscle, and digestive physiology.

Credit Hour(s): 0 OR 5

Lecture Hour(s): 0 OR 4

Instruction Type(s): Lab, Lecture, Online Lecture

Instruction Type(s): Lab, Lecture, Online Lecture

Prerequisite(s): ALS 2304 (UG) OR ALS 2304

Corequisite(s):

ALS 5324:

Research Ethics in Agriculture and Life Sciences

Principles of and skills development in research ethics to enhance professional preparation in agriculture and life sciences. Pre: Graduate standing.

Credit Hour(s): 1

Lecture Hour(s): 1

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ALS 5334:

Professional Communication Agriculture & Life Sciences

Principles of, and skill development in, academic communication to enhance professional preparation in the agricultural and life sciences. Pre: Graduate standing.

Credit Hour(s): 1

Lecture Hour(s): 1

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ALS 5404:

Management and Analysis of Agricultural Experiments

Problem-based learning approach to managing, analyzing, and interpreting experimental data common to agricultural research. Programming for statistical software packages and dissection of algorithms to troubleshoot and revise programming code.

Credit Hour(s): 3

503 Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): STAT 5615, STAT 5616

Corequisite(s):

ALS 5504:

Quantitative Genetics Applications of Matrix Algebra

Tools in quantitative genetics utilized for describing and solving problems in the agriculture and life science, with particular focus on matrix algebra. Utilize matrix algebra into genetic application, conduct matrix operations, identify the determinant and inverse of a matrix, determine linear independence, dependence and rank, use linear equations, generalized inverse, and latent roots and vectors to solve complex issues in advanced quantitative genetics. Graduate standing required.

Credit Hour(s): 1

Lecture Hour(s): 1

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ALS 5304

Corequisite(s):

ALS 5904:

Project and Report

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research, Online Research

Instruction Type(s): Research, Online Research

Prerequisite(s):

Corequisite(s):

ALS 5954:

Study Abroad

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ALS 5964:

Field Work/Practicum

NONE

Credit Hour(s): 1 TO 12

Lecture Hour(s): 1 TO 12

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ALS 5974:

Independent Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Independent Study, VI

Instruction Type(s): Independent Study, VI

Prerequisite(s):

Corequisite(s):

ALS 5984:

Special Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ALS 6314:

Endocrinology

Hormones produced in animals and their roles in development, growth, appetite, digestion, metabolism, lactation, reproduction, homeostasis, and behavior. Mechanisms by which hormones act and the factors that regulate the production and action of hormones. Endocrine disorders and hormone-based application in medicine and animal agriculture.

Major methodologies in current endocrine research.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): (ALS 5304 (UG) OR ALS 5304) OR ALS 5344

Corequisite(s):

ALS 6984:

Special Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

504 Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ALS 7964:

Field Studies

NONE

Credit Hour(s): 1 TO 12

Lecture Hour(s): 1 TO 12

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ANIMAL AND POULTRY SCIENCES

David Gerrard, Head

Professors: Rami Dalloul; Alan Ealy; Mark Estienne; David Gerrard; Scott Greiner; Honglin Jiang; Sally Johnson; James Knight; Robert Rhoads; Edward Smith; Eric Wong;

Associate Professors: Mark Cline; Joseph Eifert; Samer El-Kadi; Dan Eversole; Elizabeth Gilbert; Kiho Lee; Michael Persia; Michelle Rhoads; Cynthia Wood;

Assistant Professors: Fernando Biase; Heather Bradford; Susan Campbell; Erica Feuerbacher; Leonie Jacobs; Timothy Jarome; Caroline Leeth; Vitor Mercadante; Gota Morota; Robin White; Thomas Wilson;

John W. Hancock, Jr., Professor of Animal Science: Eric Wong;

Paul Mellon Distinguished Chair of Agriculture: Sally Johnson;

Graduate Contact: sashas5@vt.edu

Student Handbook: <http://www.apsc.vt.edu>

The Department of Animal and Poultry Sciences at Virginia Tech offers the M.S. and Ph.D. degrees. Students may specialize in the areas of genetics, genomics, immunology, management, muscle biology, nutrition, physiology, and product quality assurance. Interdisciplinary and interdepartmental programs are encouraged and students are given wide latitude to develop customized programs of study directed toward specific career goals. The department has 34 faculty members who serve the needs of about 500 undergraduate and about 50 graduate students.

SPECIAL FACILITIES

State of the art laboratories supporting all areas of graduate research are located in Litton Reaves on campus. Biosafety Level 2 animal research laboratories also are located in the building. The well-equipped laboratories offer expertise in microscopy, molecular biology, chromatography, protein chemistry and body composition (DEXA). Collaborations and partnerships with the Virginia-Maryland College of Veterinary Medicine foster access to additional animal expertise and equipment. The Department of Animal and Poultry Sciences actively

disseminates information through regional meetings and national and international symposiums and conferences. An integral component of the graduate student experience is participation in these venues.

Facilities

Animal Research Facilities The Department manages six livestock and poultry centers on-campus and at nearby Kentland Farm and the Virginia Tech Meat Science Center. These include Poultry research centers with hatcheries, grower barns, a processing facility and a feed mill for the support and management of large chicken and turkey flocks. Barns and working facilities for the management of a 300-cow beef herd.

Paddocks, pastures and stalls that house a riding herd of 40 horses and a research and teaching herd of an equal number. Farrow to finish barns that support a 70-sow swine herd. Copenhagen Sheep Center is home to 200 ewes for teaching and research. Environmental and metabolism labs capable of supporting BSL2 research in livestock and poultry are available. The Department maintains an equine exercise performance laboratory with nutrition and pasture management facilities at the Middleburg Agriculture Research and Extension Center. The historical Kentland Plantation, 20 miles from campus, provides resources for grazing and animal research. The Shenandoah Valley and Southwest Virginia Agricultural Research and Extension Centers, each 100 miles from campus, provide additional resources for beef cattle forage nutrition and management. The Tidewater Agricultural Research and Extension Center in Suffolk supports an active off-campus program in swine research and extension. Laboratory facilities In addition to the state of the art equipment located in Litton Reaves, University supported proteomic, genomic and bioinformatics core facilities are available to our faculty and students.

DEGREES OFFERED

MS Degree

Offered In (Blacksburg)

TOEFL

Paper: (550.0)

Computer: (213.0)

iBT: (90.0)

GRE

General Test: Verbal (150.0), Quantitative (150.0)

Master's Degree. The Department of Animal and Poultry Sciences allows for both thesis and non-thesis master's degrees. Minimum total graduate credits (5000-level or higher) for thesis option: 30; minimum research credits: 6; minimum graded credit hours: 20. The non-thesis option must include Project and Report: 6 hours minimum; minimum graded graduate credits for non-thesis option: 24. Seminars: minimum 1.

PhD Degree

TOEFL

Paper: (550.0)

Computer: (213.0)

iBT: (90.0)

GRE

General Test: Verbal (150.0), Quantitative (150.0)

PhD Degree. Each Ph.D. student must complete a minimum of 90 credit hours of graduate study and a dissertation. Minimum Research and Dissertation hours: 30. Minimum 5000-level or higher graded courses: 27. Seminars: minimum 2. Follow Graduate Catalog procedures.

GRADUATE COURSES (APSC)

APSC 5004:

Graduate Seminar

Students review and lead discussion of current problems and literature in Animal and Poultry Sciences. May be repeated.

Credit Hour(s): 1

Lecture Hour(s): 1

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

APSC 5014:

Professional Development of Graduate Students

Provides graduate students training and experiences to develop professional expertise as scholars, scientists and industry professionals.

Scientific method in the development of graduate research, time management, self-reflection, analysis and assessment, integrating research and teaching, ethical conduct in research and teaching, research integrity, ethical writing and avoiding plagiarism, applying critical thinking to research and teaching, professional scientific presentations, training and certification (including IACUC and new VT-specific EHS Biosafety for Research Labs). Pre: Graduate standing.

Credit Hour(s): 2

Lecture Hour(s): 2

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

APSC 5134:

Applied Behavior Analysis for Animal Behaviorists

Applied behavior analysis and behaviorism as applied to animals.

Pavlovian and operant conditioning principles to applied settings with animals, including domestic animal training and behavior consultations, captive exotic behavioral husbandry and training. Environmental manipulations including antecedent events and consequences to effect desirable behavior change. Functional relations to determine environmental causes of behavior. Common training practices in the context of evidence-based principles. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

APSC 5154:

Behavioral Biology of Domesticated Animals

Behavioral biology of domesticated animals. Biological underpinnings of behavior explored through fields of neurobiology, endocrinology, behavioral genetics, epigenetics, and population genetics. Specific processes that affect development of personality (intrauterine effects, maternal care, socialization, trauma). Domestication from anthropological, biological, and genetic perspectives. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

APSC 5184:

Research Methods for Animal Behaviorists

Research methods and data analysis. Designs relevant to applied animal behavior. Considerations for choosing a research design, hypothesis testing, choosing and defining variables, and collection methods. Single-subject research designs, including reversal, multiple baseline, multielement, and parametric. Data-based research decisions. Group designs, including factorial, nested, and parametric. Visual representation and analysis of data. Descriptive statistics and introduction to basic parametric and nonparametric statistical tests. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

APSC 5404:**Reproductive Technologies in Cattle**

Reproductive principles and techniques in dairy and beef cattle. General bovine reproductive anatomy and physiology, conventional and novel reproductive management schemes, pregnancy diagnosis, cow health concerns, nutritional considerations, environmental influences on reproductive potential, and emerging reproductive technologies.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

APSC 5444:**Contemp Issues Reprod Biology**

Current reproductive biology issues and research literature.

Physiological, molecular and cellular processes in reproduction.

Formulation of hypotheses in new and emerging areas of reproductive biology, including central nervous system control of reproduction, gametogenesis, ovarian physiology, early embryogenesis, uterine function, placental biology, fetal programming, assisted reproductive technologies, stem cell biology and emerging topics in reproductive biology. Principles of teamwork in research on reproductive biology.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ALS 5304

Corequisite(s):

APSC 5514G:**Advanced Animal Growth and Development**

Meat animal growth and development processes, micro and gross anatomy, stem cell biology and growth, body and carcass composition with application to animal and carcass evaluation. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

APSC 5554:**Mammal Genome Biology**

Mammal genome biology including structure of DNA and various modifications of DNA, including epigenetic modifications such as methylation and acetylation, and artificial modification of the genome using various genome editing technologies. Pre: Graduate standing

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

APSC 5894:**Final Examination**

For non-thesis candidates who are required to register for their final examination and have completed their program of study. Not to be included in minimum hours required for degree.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

APSC 5904:**Project and Report**

Project for non-thesis Master of Science degree. To constitute a maximum of 6 of the 45 hours required for the degree. May be repeated.

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research, Online Research

Instruction Type(s): Research, Online Research

Prerequisite(s):

Corequisite(s):

APSC 5974:**Independent Study**

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Independent Study, VI, V11

Instruction Type(s): Independent Study, VI, V11

Prerequisite(s):

Corequisite(s):

APSC 5984:**Special Study**

Credit Hour(s): 1 TO 19
Lecture Hour(s): 1 TO 19
Instruction Type(s): Lecture, Online Lecture
Instruction Type(s): Lecture, Online Lecture
Prerequisite(s):
Corequisite(s):

APSC 5994:

Research and Thesis

NONE

Credit Hour(s): 1 TO 19
Lecture Hour(s):
Instruction Type(s): Research, Online Research
Instruction Type(s): Research, Online Research
Prerequisite(s):
Corequisite(s):

APSC 6984:

Special Study

NONE

Credit Hour(s): 1 TO 19
Lecture Hour(s): 1 TO 19
Instruction Type(s): Lecture, Online Lecture
Instruction Type(s): Lecture, Online Lecture
Prerequisite(s):
Corequisite(s):

APSC 7994:

Research and Dissertation

NONE

Credit Hour(s): 1 TO 19
Lecture Hour(s):
Instruction Type(s): Research, Online Research
Instruction Type(s): Research, Online Research
Prerequisite(s):
Corequisite(s):

BIOCHEMISTRY

Glenda Gillaspy, Head

Professors: Dennis Dean; Glenda Gillaspy; Peter Kennelly; Timothy Larson;
Jianyong Li; Biswarup Mukhopadhyay; Pablo Sobrado; Zhijian Tu; Jinsong Zhu;
Associate Professors: Richard Helm; Michael Klemba; Robert White;
Assistant Professors: Anne Brown; Brandon Jutras; Chloe Lahondere; Justin Lemkul; Zachary Mackey; Daniel Slade; Clement Vinauger Tella;

Affiliated Faculty: Carla Finkielstein; Florian Schubot;
Director, Fralin Life Sciences Institute: Dennis Dean;

General Contact: smearly@vt.edu

Graduate Site: <https://www.biochem.vt.edu/Graduate/phdprogram.html>

Student Handbook: <https://www.biochem.vt.edu/Graduate.html>

The Graduate Program in the Department of Biochemistry at Virginia Tech prepares students for careers as independent researchers in biochemistry, molecular and cellular biology, biotechnology, and related areas. Training involves a combination of advanced course work, participation in seminars and journal clubs and laboratory research conducted under the guidance of a faculty committee selected by students and their faculty advisors. Incoming students participate in three laboratory research rotations to familiarize themselves with faculty and their research. The department has strengths in microbial pathogenesis and infectious disease, cell signaling, proteomics and molecular modeling. The largest cluster of faculty conducts research on infectious diseases with the ultimate aim of developing novel approaches to disease treatment and prevention. Major milestones for students are completion of an oral qualifying examination, an oral preliminary examination which also requires writing an NIH-style research proposal, and writing and defense of a research dissertation. Students also present their research at national and international conferences and participate in more informal training opportunities, including university-wide scientific writing and grant proposal preparation workshops. Our students typically complete their Ph.D.s within five years and pursue a variety of careers including positions in academia, industry and state and federal government.

SPECIAL FACILITIES

Biochemistry is just one facet of a large and vibrant life science research enterprise at Virginia Tech. Our faculty study a range of biochemical problems using cutting edge research equipment and facilities. In collaboration with the Fralin Life Science Institute, our department is home to a proteomics and metabolomics facility. Our students also have access to core facilities for confocal microscopy, fermentation, protein purification, DNA sequencing, flow cytometry, real-time PCR, and microarray analysis. Virginia Tech is known for its interdisciplinary graduate training. Research strengths include infectious disease, obesity, microbial pathogenesis, and eukaryotic cell signaling. Biochemistry students and faculty are active in each of these areas. Students also have opportunities to interact with scientists from across the country and around the world through the interdepartmental Virginia Tech Life Sciences seminar series. The individual laboratories within the department are well equipped for modern biochemical, molecular biological, and microbiological research. Available equipment include a comprehensive suite of mass spectrometers for proteomic analyses, standard and microplate fluorometers, stopped-flow spectrometer with fluorescence excitation for rapid kinetic analysis, UV-visible photodiode array spectrophotometer, a robotic workstation for high-throughput screening, real-time PCR thermocyclers, liquid chromatography systems, systems for electronic autoradiography and fluorescent/chemiluminescent imaging, and tissue culture and insect rearing facilities. Numerous shared on-campus resources enhance the research opportunities available to students. These include the Keck Confocal Microscope Facility, the Keck Transgenic Plant Greenhouse, the Fralin Fermentation and Protein Purification Facility, and the Flow Cytometry Core Facility. Access to NMR spectrometers and X-ray diffractometers is available through the Departments of Chemistry and

Biological Sciences. The Core Computation and Laboratory Facilities at the Virginia Bioinformatics Institute provide a range of bioinformatic, DNA-sequencing, and genomic/proteomic services. The VT CAVE is a multiperson, room-sized, high-resolution, 3-D video and audio environment that can be used to visualize a wide variety of biological molecules in 3-D space.

Biochemistry Facilities

Our students also have access to core facilities for confocal microscopy, fermentation, protein purification, DNA sequencing, flow cytometry, real-time PCR, and microarray analysis. In collaboration with the Fralin Life Science Institute, our department is home to the center for drug discovery screening laboratory, and proteomics and metabolomics facility.

DEGREES OFFERED

PhD Degree

Offered In (Blacksburg)

TOEFL

Paper: (577.0)

Computer: (233.0)

iBT: (90.0)

Doctoral students take a set of core courses and at least two specialized courses within their research track during their first two years. Students also complete laboratory rotations (first year) and seminars (all years). Students are typically funded by the department during the first three semesters of laboratory rotation. Most students will work as a teaching assistant for two of those semesters. Ph.D. candidates must also maintain a cumulative GPA of 3.0 or above in all coursework, and complete the following requirements: - Students must meet all course and research credit hour requirements of the Graduate School. - 27 hours of courses numbered 5000 or higher, may include up to 4 hours of seminar. - Complete a minimum of 90 semester hours of graduate study. - Pass the qualifying examination at the end of the first year. - Pass the preliminary examination at the end of the second year. - Write and successfully defend a research-based dissertation. A complete description of the Academic requirements for Ph.D. Degree is also available in the Graduate Student Handbook (<https://www.biochem.vt.edu/Graduate/phdprogram.html>).

MSLFS Degree

Offered In (Blacksburg)

TOEFL

Paper: (577.0)

Computer: (233.0)

iBT: (90.0)

The Master of Science in Life Sciences merges the efforts of the departments of Biochemistry, Entomology, Food Science and Technology, and Plant Pathology, Plant Physiology, and Weed Science. Students in basic and applied disciplines in the College of Agriculture and Life Sciences share common experiences that prepare them for

careers in which interdisciplinary interactions become increasingly valued. At the same time, discipline-specific education and research experience, which characterizes the M.S. in Life Sciences program in each department, prepares students for unique positions and career development. For graduation, students must complete a minimum of 20 graded credit hours and 30 total credit hours. Specific course requirements* include Biometry (STAT 5605) Protein Struct & Fxn (BCHM 5224, 3 hours), Adv Applic in Mol Life Sci (BCHM 5784, 3 hours) and Research Ethics in Ag & Life Sci (ALS 5324, 1 or 2 hours). All students must present a seminar and defend a thesis describing the results of their research as a final step for the completion of M.S. degree requirements (a non-thesis MS option is also available). *Substitutions must be approved, in advance, by the student's advisory committee and ratified by the Graduate School.

PhD Degree

Offered In (Blacksburg)

TOEFL

Paper: (577.0)

Computer: (233.0)

iBT: (90.0)

Doctoral students take a set of core courses and at least two specialized courses within their research track during their first two years. Students also complete laboratory rotations (first year) and seminars (all years). Students are typically funded by the department during the first three semesters of laboratory rotation. Most students will work as a teaching assistant for two of those semesters. Ph.D. candidates must also maintain a cumulative GPA of 3.0 or above in all coursework, and complete the following requirements: - Students must meet all course and research credit hour requirements of the Graduate School. - 27 hours of courses numbered 5000 or higher, may include up to 4 hours of seminar. - Complete a minimum of 90 semester hours of graduate study. - Pass the qualifying examination at the end of the first year. - Pass the preliminary examination at the end of the second year. - Write and successfully defend a research-based dissertation. A complete description of the Academic requirements for Ph.D. Degree is also available in the Graduate Student Handbook (<https://www.biochem.vt.edu/Graduate.html>).

MSLFS Degree

Offered In (Blacksburg)

TOEFL

Paper: (577.0)

Computer: (233.0)

iBT: (90.0)

The Master of Science in Life Sciences merges the efforts of the departments of Biochemistry, Entomology, Food Science and Technology, and Plant Pathology, Plant Physiology, and Weed Science. Students in basic and applied disciplines in the College of Agriculture and Life Sciences share common experiences that prepare them for careers in which interdisciplinary interactions become increasingly valued. At the same time, discipline-specific education and research experience, which characterizes the M.S. in Life Sciences program in each department, prepares students for unique positions and career development. For graduation, students must complete a minimum of 20

graded credit hours and 30 total credit hours. Specific course requirements* include Biometry (STAT 5605) Protein Struct & Fxn (BCHM 5224, 3 hours), Adv Applic in Mol Life Sci (BCHM 5784, 3 hours) and Research Ethics in Ag & Life Sci (ALS 5324, 1 or 2 hours). All students must present a seminar and defend a thesis describing the results of their research as a final step for the completion of M.S. degree requirements.*Substitutions must be approved, in advance, by the student's advisory committee and ratified by the Graduate School.

GRADUATE COURSES (BCHM)

BCHM 5004:

Seminar in Biochemistry

Review and discussion of current problems and literature in biochemistry and nutrition. Student presentation of research results, faculty research, and visiting lecturers. May be repeated. Biochemistry majors only.

Credit Hour(s): 1

Lecture Hour(s): 1

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

BCHM 5014:

Techniques in Biochemical Research

Application of modern biochemical concepts and techniques in research on protein and nucleic acid biochemistry, structure, function, gene expression and organization; microbial metabolism coenzyme biosynthesis; structure and function of membranes and subcellular organelles. Pre-requisite: Graduate standing in Biochemistry. May be repeated once for credit.

Credit Hour(s): 4

Lecture Hour(s):

Instruction Type(s): Lab

Instruction Type(s): Lab

Prerequisite(s):

Corequisite(s):

BCHM 5024:

Computational Biochemistry for Bioinformatics

Applications of protein structure and function, protein characterization, enzyme kinetics, and analysis of metabolic control for students with a background in computer science, mathematics, statistics, or engineering. Pre: B.S or senior standing in computer science, mathematics, statistics, or engineering. Not available to life science majors for credit.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

BCHM 5064 (BIOL 5064) (ALS 5064):

Seminar in Molecular Cell Biology and Biotechnology

Review and discussion of current problems and literature in molecular cell biology and biotechnology by students, VPI&SU faculty and outside speakers. Students give formal presentations of research results or current literature. May be taken on pass-fail basis. Students enrolled in the MCBB Ph.D. option will be required to give one formal presentation on an A-F basis. Graduate status in participating MCBB departments required.

Credit Hour(s): 1

Lecture Hour(s): 1

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

BCHM 5124:

Biochemistry for the Life Sciences

Basic principles of biochemistry including protein structure, enzymology, gene expression, bioenergetics, and pathways of energy metabolism.

Not available to Biochemistry majors.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): CHEM 2536 (UG)

Corequisite(s):

BCHM 5204:

Molecular Biology of Eukaryotic Gene Expression

Current concepts and research approaches of eukaryotic gene expression. Chromatin remodeling. Noncoding ribonucleic acids. Epigenetics. Genomic, epigenomic and transcriptomic data analysis. Genome editing technology. High-throughput approaches to profiling. Critical review of current research. Research design and proposals. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

BCHM 5224:**Protein Structure and Function**

Structure and function of proteins. Topics include special techniques in protein purification and characterization, techniques for studying protein structure, posttranslational modification of proteins and selected topics to study the structure-function relationship of proteins. Taught alternate years.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): (BCHM 4115 (UG) OR BCHM 5115 (UG) OR BCHM 5124 (UG)) OR (BCHM 4115 OR BCHM 5115 OR BCHM 5124)

Corequisite(s):

Lecture Hour(s): 1 TO 19

Instruction Type(s): Independent Study

Instruction Type(s): Independent Study

Prerequisite(s):

Corequisite(s):

BCHM 5984:**Special Study**

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

BCHM 5344 (PPWS 5344):**Molecular Biology for the Life Sciences**

A multi-disciplinary treatment of gene organization and expression in animal and plant systems. Emphasis on the applications of molecular biology to current problems in applied biology and biotechnology.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): (BCHM 4116 (UG) OR BCHM 5124 (UG)) OR (BCHM 4116 OR BCHM 5124)

Corequisite(s):

BCHM 5994:**Research and Thesis**

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research

Instruction Type(s): Research

Prerequisite(s):

Corequisite(s):

BCHM 5784G:**Adv Apps Molecular Life Sci**

Synthesis and application of biochemistry, cell biology, genetics, genomics, physiology, immunology concepts and techniques to address medical and agricultural problems. Genre characterization and manipulation, protein-based drugs, diagnostics, vaccines, transgenic plants/animals. Advanced analysis, critique, application of research in molecular life science. Prerequisite: Graduate Standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

BCHM 6984:**Special Study**

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

BCHM 7994:**Research and Dissertation**

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research

Instruction Type(s): Research

Prerequisite(s):

Corequisite(s):

BCHM 5974:**Independent Study**

NONE

Credit Hour(s): 1 TO 19

CROP AND SOIL ENVIRONMENTAL SCIENCES

Michael Evans, Head

Emeriti Faculty: Marcus Alley;

Professors: Azenegashe Abaye; Walter Daniels; Matthew Eick; Gregory Evanylo; James Goatley; Carl Griffey; Steven Hodges; Mohammad Saghai-Maroo;

Associate Professors: John Fike; John Galbraith; David Holshouser; Rory Maguire; Mark Reiter; Wade Thomason; Benjamin Tracy; Carol Wilkinson; Kang Xia;

Assistant Professors: Brian Badgley; William Frame; Song Li; Meredith Steele; Ryan Stewart;

Research Faculty: Thomas Reed; Bo Zhang;

Thomas B. Hutcheson Professor: Walter Daniels;

W.G. Wysor Professor: Carl Griffey;

General Contact: spesgradinfo@vt.edu

Graduate Site: <https://spes.vt.edu/>

Graduate programs in Crop and Soil Environmental Sciences (CSES) are part of the School of Plant & Environmental Sciences (SPES) and lead to both the M.S. (non-thesis and thesis options) and the Ph.D. degrees. The principal objective of graduate education programs is to educate students in advanced concepts and research methods in one or more subdisciplines of CSES and related programs. This is accomplished through courses and research that bridge the physical and biological sciences. Individually planned programs of study are developed to provide education and experience in the general areas of focus for the department: 1) agronomy, 2) crop breeding and genomics, and 3) environmental science of soil and water in intensively managed landscapes. Graduate study programs in CSES are interdisciplinary by nature. The School and CSES also manage a "Direct to Ph.D." program and participate in several interdisciplinary M.S. and Ph.D. programs.

SPECIAL FACILITIES

The department has modern and extensive laboratory and field facilities and equipment for many research and teaching applications of crop, soil and environmental sciences. SPES, CSES and allied departments have the equipment necessary for cutting-edge research on crop response to inputs and management, crop physiology, traditional and molecular breeding of crops, next-generation sequencing of plant and microbial genomes, computational biology, environmental quality of degraded ecosystems, impacts of land use on ecosystem services, fate and transport of contaminants in air, water, and soil; and bioavailability and transformations of nutrients in soil and water,

Overall facility summary

See our website at www.vt.cses.edu for information on our programs and facilities.

DEGREES OFFERED

PhD Degree

Offered In (Blacksburg)

TOEFL

Paper: (550.0)

Computer: (213.0)

iBT: (90.0)

GRE

General: Verbal (150.0), Quantitative (150.0), Analytical (4.0)

Establishing a Committee - The major advisor and student will select an Advisory Committee no later than the end of the first semester of residence. The minimum number of members for the advisory committee are 3 for M.S. students, and 4 for Ph.D. students. The Ph.D. committee must have at least one member from outside the School. At this meeting, the committee will become familiar with the student's training, background, and research interests. The committee also will orient and advise the student regarding research and course-work. Plan of Study : Students are expected to present to their major advisor a draft Program of Study that meets all requirements. After review and approval by the major advisor, the Plan of Study must be reviewed and approved by all members of the students advisory committee. After approval, the Plan of Study is submitted to the Graduate School through the Student Administration Center in the School. It is the student's responsibility to see that the Plan Study is submitted to the Graduate School on time (prior to completing 12 credit hours toward the M.S. degree, and before completing 18 credit hours beyond the M.S. toward the Ph.D. degree). Changes to the Plan of Study must be approved by the advisory committee and submitted to the Graduate School through the Student Administration Center. Research Proposal - As research is initiated for a degree, a Research Proposal will be presented in writing and orally to the student's Advisory Committee. This proposal should include sections containing: (a) an abbreviated literature search; (b) clear and concise objectives; (c) proposed experimental procedures; and (4) data analysis and presentation procedures. The purpose of this requirement is to determine whether the research proposed is adequate to satisfy degree requirements and to assist the student in clarifying objectives and procedures. The time to present the proposal will be determined by the major advisor and the committee. Students are encouraged to begin this process as soon as possible in order to complete their studies in a timely manner and with minimal wasted efforts! Report on Research - Each graduate student will present an annual progress report to his/her Advisory Committee and other interested persons prior to the final examination. The purpose of such reports is to evaluate the research progress and make suggestions for modifications or additions to the research objectives or procedures. A one page summary evaluation of the annual report is to be provided to the Graduate Coordinator. Preparation of Theses/Dissertations or Non-Thesis M.S. Project Reports - The student, with the assistance of his or her major professor, has the responsibility for preparation of the thesis/dissertation/project report. While the Graduate School specifies certain formats, it leaves matters of style largely to departments, but urges that the style conform to the major professional or scientific journals in the student's area of interest. Therefore, the CSES program suggests that theses/dissertations/project reports follow the style of journals of the American Society of Agronomy, Soil Science Society of America, or other sources acceptable by the committee. Students may find that certain mechanical considerations for manuscripts will differ between journals and those specified by the Graduate School. Follow the Graduate Policies and Procedures in such cases. Preparation of the thesis/dissertation/project report in proper style will facilitate the preparation of manuscripts for publication. All theses

and dissertations must be submitted to the Graduate School in electronic format. Seminars are given by the Graduate School each semester to familiarize students with the procedures needed to prepare the electronic submission. Students are expected to know these procedures and prepare the thesis or dissertation to meet all requirements. Each section of the thesis/dissertation/project report should be prepared to the satisfaction of the Major Professor before being given to the other members of the Advisory Committee for review. Each section is to be provided to the committee members as it is completed. All sections of the thesis/dissertation are to be reviewed by the committee at least 14 days prior to the examination. Students will provide the members of the Advisory Committee the complete and revised thesis/dissertation at least 7 days prior to the oral examination/defense. Even though each member of the Advisory Committee will have provided suggestions or requirements for revisions of the thesis/dissertation/project report prior to the final examination, some corrections or additions will always be necessary even following a successful final examination. The Graduate School generally allows a period of two weeks after the final examination to submit the final version of the thesis or dissertation. The final project report is submitted only to the Major Advisor and Advisory Committee.

Foreign Language Requirement - The department does not require a foreign language for any degree.

MS Degree

Offered In (Blacksburg)

TOEFL

Paper: (550.0)

Computer: (213.0)

iBT: (90.0)

GRE

General: Verbal (150.0), Quantitative (150.0), Analytical (4.0)

Establishing a Committee - The major advisor and student will select an Advisory Committee no later than the end of the first semester of residence. The minimum number of members for the advisory committee are 3 for M.S. students, and 4 for Ph.D. students. The Ph.D. committee must have at least one member from outside the School. At this meeting, the committee will become familiar with the student's training, background, and research interests. The committee also will orient and advise the student regarding research and course-work. Plan of Study : Students are expected to present to their major advisor a draft Program of Study that meets all requirements. After review and approval by the major advisor, the Plan of Study must be reviewed and approved by all members of the students advisory committee. After approval, the Plan of Study is submitted to the Graduate School through the Student Administration Center in the School. It is the student's responsibility to see that the Plan Study is submitted to the Graduate School on time (prior to completing 12 credit hours toward the M.S. degree, and before completing 18 credit hours beyond the M.S. toward the Ph.D. degree. Changes to the Plan of Study must be approved by the advisory committee and submitted to the Graduate School through the Student Administration Center. Research Proposal - As research is initiated for a degree, a Research Proposal will be presented in writing and orally to the student's Advisory Committee. This proposal should include sections containing: (a) an abbreviated literature search; (b) clear and concise objectives; (c) proposed experimental procedures; and (4) data analysis and presentation procedures. The purpose of this requirement is to determine whether the research proposed is adequate to satisfy degree requirements and to assist the student in clarifying objectives and procedures. The time to present the proposal will be determined by the

major advisor and the committee. Students are encouraged to begin this process as soon as possible in order to complete their studies in a timely manner and with minimal wasted efforts! Report on Research - Each graduate student will present an annual progress report to his/her Advisory Committee and other interested persons prior to the final examination. The purpose of such reports is to evaluate the research progress and make suggestions for modifications or additions to the research objectives or procedures. A one page summary evaluation of the annual report is to be provided to the Graduate Coordinator.

Preparation of Theses/Dissertations or Non-Thesis M.S. Project Reports - The student, with the assistance of his or her major professor, has the responsibility for preparation of the thesis/dissertation/project report. While the Graduate School specifies certain formats, it leaves matters of style largely to departments, but urges that the style conform to the major professional or scientific journals in the student's area of interest. Therefore, the School suggests that theses/dissertations/project reports follow the style of journals of the American Society of Agronomy, Soil Science Society of America, or other sources acceptable by the committee. Students may find that certain mechanical considerations for manuscripts will differ between journals and those specified by the Graduate School. Follow the Graduate Policies and Procedures in such cases. Preparation of the thesis/dissertation/project report in proper style will facilitate the preparation of manuscripts for publication. All theses and dissertations must be submitted to the Graduate School in electronic format. Seminars are given by the Graduate School each semester to familiarize students with the procedures needed to prepare the electronic submission. Students are expected to know these procedures and prepare the thesis or dissertation to meet all requirements. Each section of the thesis/dissertation/project report should be prepared to the satisfaction of the Major Professor before being given to the other members of the Advisory Committee for review. Each section is to be provided to the committee members as it is completed. All sections of the thesis/dissertation are to be reviewed by the committee at least 14 days prior to the examination. Students will provide the members of the Advisory Committee the complete and revised thesis/dissertation at least 7 days prior to the oral examination/defense. Even though each member of the Advisory Committee will have provided suggestions or requirements for revisions of the thesis/dissertation/project report prior to the final examination, some corrections or additions will always be necessary even following a successful final examination. The Graduate School generally allows a period of two weeks after the final examination to submit the final version of the thesis or dissertation. The final project report is submitted only to the Major Advisor and Advisory Committee.

Foreign Language Requirement - The department does not require a foreign language for any degree.

GRADUATE COURSES (CSES)

CSES 5044:

Modeling Managed Ecosystems and Complexity

Introduction to systems thinking, diverse approaches to problem framing and modeling in managed ecosystems, and system dynamics model development processes. Application of theory, formal problem articulation, model conceptualization and formalization, testing, and analysis for decision support in agriculture, urban, and disturbed ecosystems. Pre: Graduate Standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CSES 5064:

Turfgrass Science Seminar

Critical review of current journal articles addressing research topics in turfgrass physiology, ecology, cultural programming, pathology, entomology, and weed science. Pre-requisite: Graduate Standing required.

Credit Hour(s): 2

Lecture Hour(s): 2

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CSES 5114:

Soils for Professionals

Characterization of soils as a natural resource emphasizing their physical, chemical, mineralogical, and biological properties in relation to nutrient availability, fertility, plant growth, land-use management, waste application, soil and water quality, and food production. Calculations used in land-use management. Pre: One year of introductory biology and chemistry. Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CSES 5124:

Topics in Soil Genesis

Topics in soil genesis of regional interest will be addressed. This is a one-week field course that will rotate each year among four regions in the northeastern United States. The regions are Virginia-Maryland, Pennsylvania-West Virginia, New York, and the New England states. This will provide students the opportunity to observe and study soils in the field over a much broader geographic area that otherwise is not possible in a conventional semester course. May be repeated.

Credit Hour(s): 1

Lecture Hour(s):

Instruction Type(s): Lab, Lecture

Instruction Type(s): Lab, Lecture

Prerequisite(s): CSES 4134 (UG) OR CSES 4134

Corequisite(s):

CSES 5144 (FREC 5144):

Watershed Hydrology

Physical concepts of hydrological processes that affect age, origin, cycling, and flowpaths of water within watersheds. Analysis of current and historical research methods. Hydrological science as an interdisciplinary topic. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

CSES 5214:

Soil-Plant Relationships

An interdisciplinary study of soil-plant relationships, with particular emphasis placed on soil chemical and physical properties and their influence on plant growth and development. Topics studied include: root growth, soil compaction, water in the soil-plant-atmosphere continuum, soil acidity, nutrient movement to plant roots, soil aeration, and nitrogen in the soil-plant environment.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): CSES 4214 (UG) OR CSES 4214

Corequisite(s):

CSES 5304:

Advanced Plant Genetics and Breeding

Plant breeding theory and methodology for the improvement of argonomic and horticultural crops; genetic diversity; polyploidy; gene inheritance, expression, interaction, and stability; incompatibility; male sterility; haploidy; genetic engineering and transformation; parental selection, hybridization, and population development; breeding methods, genotypic and phenotypic line selection and evaluation; strategies for cultivar development including marker assisted selection and breeding for durable disease resistance. Graduate standing required.

Credit Hour(s): 4

Lecture Hour(s): 3

Instruction Type(s): Lab, Lecture, Online Lecture

Instruction Type(s): Lab, Lecture, Online Lecture

Prerequisite(s): CSES 4144 (UG) OR CSES 4144 OR BIOL 2004 (UG)

514 OR BIOL 2004

Corequisite(s):

CSES 5314:

Water Quality for Professionals

Global water resource sustainability and management. Current water quality policies. Physical, chemical, biological, and anthropogenic factors affecting water quality, fate and transport of contaminants in water.

Approaches of water quality risk assessment. Water treatment and management technologies. Pre: Graduate Standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CSES 5324:

Blending Business and Environmental Principles

Relationship between environmental principles and business planning.

Strategies and methods for practical application that are mutually supportive to both environmental and business goals. Methods to communicate environmental risks to stakeholder groups. Environmental ethics in business, environmental decision making, competitive advantage through sustainability, environmental law in practice, public engagement strategies, and linking environmental performance to business strategies . Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CSES 5344:

Advanced Crop Physiology

Physiological considerations in a crop community: light interception, gas exchange, water stress, flowering, and senescence; key metabolic processes that most directly affect yield: photosynthesis (C3 and C4), photorespiration, and N-metabolism; cropping systems as symbioses.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): CSES 4344 (UG) OR CSES 4344

Corequisite(s):

CSES 5444:

Applied Agronomic Topics for the Mid-Atlantic

Current operational and applied issues related to agronomic crop production systems in the Mid-Atlantic region. Nutrient, soil and water, pest and crop management issues and associated best management practices. Preparation for national Certified Crop Advisor examination.

Pre: Graduate standing

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

CSES 5544:

Soil-plant-animal Interrelationships in Grasslands

The principles of plant competition and succession during the establishment and maintenance of herbaceous species and communities are interrelated to soil, biotic, and microclimatic factors and their interactions. Ecological and nutritional principles embodying plant and animal factor in the utilization of herbaceous plants by livestock are established. Research methodology in grassland systems is presented.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): (CSES 4214 (UG), CSES 4544 (UG), ALS 3204 (UG)) OR (CSES 4214, CSES 4544, ALS 3204)

Corequisite(s):

CSES 5554:

Ecology of Grazing Land Systems

A multi-disciplinary, multi-institution, field course. Students travel through diverse ecosystems studying the components and functions of grazing lands. Attention is to: (a) how components and functions vary to ecoregion; (b) research needs, objectives, and techniques in soil-plant - animal research; (c) forage-livestock ecology and systems in crop-, pasture-, range-, and forestlands; (d) the role of forages in conservation, wildlife habitat, and sustainable agriculture; and (e) industries involved with forages and livestock. X grade applies.

Credit Hour(s): 3

Lecture Hour(s): 1

Instruction Type(s): Lab, Lecture, Online Lecture

Instruction Type(s): Lab, Lecture, Online Lecture

Prerequisite(s): CSES 4544 (UG) OR CSES 5544 (UG) OR CSES 4544 OR CSES 5544

Corequisite(s):

CSES 5604:**Environmental Science Concepts for Professionals**

Physical, chemical, and biological principles and processes that are central to human-environment interactions. Emphasizes air and water resources and the role of energy in human and natural systems. Major U.S. environmental legislation and regulations. Pre: Two semesters each of college chemistry and biology and one semester of economics.

Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CSES 5634:**Soil Chemistry**

Chemical and colloidal properties of clays and organic matter in soil systems including ion exchange, retention and precipitation; soil acidity and salinity; mineral weathering and formation; oxidation-reduction reactions; trace and toxic elements, and organic pollutants in soils. Pre:

Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

CSES 5694:**Soil Biochemistry**

Comprehensive presentation and analysis of the biochemistry of soil humic acid formation, physicochemical properties of humic substances, and interactions of soil humic substances with toxic organics and metals. Microbial degradation of organics, including pesticides, and the fate of genetically engineered microbes in soil.

Credit Hour(s): 3

Lecture Hour(s): 2

Instruction Type(s): Lab, Lecture, Online Lecture

Instruction Type(s): Lab, Lecture, Online Lecture

Prerequisite(s): (CSES 4684 (UG), CSES 4694 (UG), BIOL 4684 (UG)) OR (CSES 4684, CSES 4694, BIOL 4684)

Corequisite(s):

CSES 5744G:**Adv Managed Ecosys Serv & Sust**

Interactions of climate, soils, and organisms within intensively managed

ecosystems used to produce food, energy, water, recreation, and other essential ecosystem services. Models of ecosystem development, role of disturbance, application of ecological theory and concepts to agricultural, grassland, and urban/turf ecosystems. Regional and global significance in sustainable food systems, and global ecosystem assessment. Pre-requisite: Graduate Standing and knowledge of basic soil science required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CSES 5764G:**Advanced Bioremediation**

Environmental biotechnology and use of microbes and other organisms to remove contaminants and improve environmental quality. Treatment of contaminated soils, waters, and wastewaters; remediation of industrial waste streams. Current topics and future directions in biodegradation research. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CSES 5774:**Advanced Rehabilitation of Disturbed Lands**

Advanced study of human disturbance of soils and landscapes and various remediation strategies. Global environmental impacts of coal and metal mining, mineral processing, highway-utility corridor development, and urbanization. Acid mine drainage and treatment, including use of artificial wetlands. Study tours and field project. May not be taken after CSES 4774 or CSES 5874. Graduate standing required.

Credit Hour(s): 4

Lecture Hour(s): 3

Instruction Type(s): Lab, Lecture, Online Lecture

Instruction Type(s): Lab, Lecture, Online Lecture

Prerequisite(s): CSES 4124 (UG) OR CSES 4124 OR CSES 4134 (UG) OR CSES 4134 OR MINE 4544 (UG) OR MINE 4544

Corequisite(s):

CSES 5844:**Plant Genomics**

Comprehensive overview of genomics and its applications. Topics

include: molecular markers, map construction, map-based cloning, quantitative trait loci, and functional genomics. Even Years. Pre: Knowledge of general principles of genetics and molecular biology.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): CSES 4144 (UG) OR CSES 4144

Corequisite(s):

CSES 5854:

Advanced Wetland Soils

Wetlands soils as components of natural landscapes: biogeochemistry, hydrology, geomorphology, hydric soil indicators, and wetland functions under various land uses. Soil and hydrologic factors important to wetland delineation and jurisdictional determination. Mitigation of wetland impacts with emphasis on restoration and creation. Outdoor lectures at local wetlands and a two-day long field trip to observe and identify wetland soils are mandatory. Pre: Graduate standing.

Credit Hour(s): 4

Lecture Hour(s): 3

Instruction Type(s): Lab, Lecture, Online Lecture

Instruction Type(s): Lab, Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

CSES 5864:

Advanced Wetland Soils and Mitigation

Wetland soils as components of natural landscapes and their interactions with hydrologic systems. Hydric soil identification and delineation, preparation of wetland water budgets, restoration of damaged wetlands, and creation of compensation wetlands. Utilization of advanced soil information systems and GIS/GPS in wetlands study. Constructed wetlands for nutrient removal and acid mine drainage treatment.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): CSES 5114 (UG) OR CSES 5114

Corequisite(s):

CSES 5874:

Reclamation of Disturbed Lands

Human disturbances of soils and landscapes and various remediation strategies. Environmental impacts of coal and metal mining, mineral processing, highway or utility corridor development, and urbanization.

Field and lab testing protocols; development of site-specific revegetation protocols. Acid mine drainage and treatment, including use of artificial wetlands.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): CSES 5114

Corequisite(s):

CSES 5904:

Project and Report

Project for non-thesis Masters of Science degree option. To constitute 3 to 6 of the 30 credit hours required for the degree. This course will emphasize critical interpretation, review, and oral/written reporting of an assigned topic. Review grade only. May be repeated.

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research, Online Research

Instruction Type(s): Research, Online Research

Prerequisite(s):

Corequisite(s):

CSES 5974:

Independent Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Independent Study

Instruction Type(s): Independent Study

Prerequisite(s):

Corequisite(s):

CSES 5984:

Special Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lab, Lecture, Online Lecture

Instruction Type(s): Lab, Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

CSES 5994:

Research and Thesis

NONE

517 Credit Hour(s): 1 TO 19

Lecture Hour(s):
Instruction Type(s): Research
Instruction Type(s): Research
Prerequisite(s):
Corequisite(s):

CSES 7994:

Research and Dissertation

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research

Instruction Type(s): Research

Prerequisite(s):

Corequisite(s):

DAIRY SCIENCE

David Gerrard, Interim Head

Professors: Mark Hanigan; Katharine Knowlton;

Associate Professors: Benjamin Corl; Kristy Daniels; Gonzalo Ferreira; Christina Petersson-Wolfe;

Assistant Professors: Rebecca Cockrum;

David R. and Margaret Lincicome Professor of Agriculture: Mark Hanigan;

Colonel Horace E. Alphin Professor: Katharine Knowlton;

Benjamin Corl: bcorl@vt.edu

Student Handbook: <http://www.dasc.vt.edu>

The Dairy Science Department recognizes the significant contributions made by graduate students to departmental research, teaching, and extension programs and is committed to providing the best possible opportunity for students to learn and develop as professionals in their areas of interest. Application Process The GRE exam is required for all applicants. The results of the Test of English as a Foreign Language (TOEFL) is required for applicants who did not receive their bachelor's degrees from an Anglophone university and whose first language is not English. We currently expect a minimum TOEFL score of 90 (IBT) or IELTS score of 6.5 for admission. Further, TOEFL scores of 20 or greater in Listening, Writing, Speaking, and Reading subsections are required. Three letters of recommendation are required. We strongly encourage applicants to have online recommendations completed. Applicants are asked to provide names and email addresses for each reference in the online application. If applicants choose to have paper letters of recommendation submitted, the letters should be sent to the attention of Becky Michael in the Dairy Science Department. It is expected that applicants should be near completion of a B.S. or M.S. degree in animal or dairy science, biology, microbiology, biochemistry, related biological fields, agricultural economics, or agricultural finance. Students should have a 3.0 GPA or greater and strong scientific writing

and communication skills. Students are strongly encouraged to apply online. Applying online streamlines the application process and reduces processing time. Applicants must pay a \$75 non-refundable fee. Terms of Employment Many graduate students in Dairy Science receive financial support in the form of a graduate research assistantship or graduate teaching assistantship. Since all students conduct research as a part of degree requirements and most students assist in some way with the teaching of classes, the Department of Dairy Science makes no meaningful distinction between graduate research and teaching assistantships. Some students are recipients of fellowships awarded through the College, University, or Graduate School, and a few are supported by their own funds or funds from their home country, in the case of some international students. Regardless of the source or amount of support, all graduate students are considered to be half time employees of the department. As such, graduate students are expected to work 20 hours per week (50 weeks per year with two weeks paid vacation) in support of departmental research, teaching, and/or extension programs. Much of this is related to the thesis or dissertation research conducted by all students and is heavily concentrated in the latter stages of a student's degree program. However, graduate students also are expected to contribute to departmental research projects, assist in classroom teaching, and participate in extension programs as requested by their faculty supervisors, to whom they are directly responsible. Participation in departmental research, teaching and extension activities serves not only to support departmental programs, but also to train students in areas important to eventual career success.

SPECIAL FACILITIES

The Department has laboratory and animal facilities to support its missions in teaching, research, and extension.

Laboratories

The Department resides in Litton Reaves Hall, a modern, well equipped, office building. In addition to offices, it includes extensive laboratory space with state of the art equipment and classroom facilities.

Laboratories supporting physiology, molecular biology, nutrition, health, and quantitative research are included.

Virginia Tech Dairy

The Virginia Tech Dairy Science Complex is located at Kentland Farm. Lactating cows are housed in a 232 stall freestall barn where feed consumption can be monitored for research. The barn features drovers alleys on both sides and research pens on one side. It is double sloped to middle and utilizes sand bedding. The sand is recycled using a weeping wall system for manure management. The milking facility is designed for animal handling with a double 12 parallel parlor and houses administrative offices. There is also a special needs barn for use with weaned calves, breeding age heifers and close up dry cows. Additionally, there's a calf barn with automatic feeders and weaned calf pens. Facilities and equipment for research with all ages of animals are present at the farm and support both applied and basic research in the department.

DEGREES OFFERED

MSLFS Degree

Offered In (Blacksburg)

TOEFL

Paper: Minimum (577.0)

Computer: Minimum (233.0)

iBT: Minimum (90.0)

GRE

Average Scores of Candidates: Verbal (150.0), Quantitative (165.0),

Analytic Writing (3.5)

Graduate Advisory Committee All students are assigned a faculty supervisor (major professor) prior to, or immediately after initial enrollment. Assignments should be mutually agreeable to both student and faculty member, and each faculty supervisor should have an active research program in the area of student interest. Within the first or second semesters of enrollment, each student should work with his/her faculty supervisor to establish an advisory committee (three members for MS committees; four for Ph.D. committees) to assist in the development of a program of study and completion of the thesis or dissertation research project. Advisory Committee members are expected to provide appropriate and timely input to the academic and research programs of the student. Conversely, both students and faculty supervisors are expected to assure appropriate involvement of the advisory committees in each student's program. Students should discuss any problems related to their advisory committee with their faculty supervisor and, if needed, with the department head.

Credit Hour Loads Full-time credit hour loads are 12 hours in Fall and Spring semesters (in addition to courses audited). Typically, students will register for 6 to 9 hours of formal course work (2 to 3 classes) during Fall and Spring terms (or less during the latter stages of a graduate program), and for sufficient hours of Research and Thesis (MS) or Research and Dissertation (PhD) credits to complete the 12-hour, full-time load. Note that this is required for payment of assistantships and for progression from assistantship step 1 to step 2, since step 2 requires the completion of 24 credit hours. Students who, prior to the beginning of a semester, will have 1) fulfilled all residency and course requirements 2) scheduled their final exam to take place by the Friday of the third week of classes and 3) submit a final thesis or dissertation to their committee during the first three weeks of the semester, are eligible to request registration for 1 hour as Start of Semester Defense Exception. A certification form, available from the departmental office, must be submitted to the Graduate School in order to be registered as Start of Semester Defense Exception. Registration may affect eligibility for assistantships and certain student benefits and/or loans since students so registered do not pay the comprehensive fee and are not classified as full-time students.

Evaluation of Performance and Progress toward Degree In an effort to foster communications between graduate students, their faculty supervisors, and advisory committees, the Dairy Science Department requires an annual evaluation and communication of graduate student performance and progress toward either the M.S. or Ph.D. degree. The process is initiated with a written report, from each graduate student to his/her faculty supervisor, which appropriately details the graduate student's academic and research program progress during the preceding year. The form of the report is the prerogative of the faculty supervisor and due by February 1st of each year or earlier as designated by the faculty supervisor. In response, faculty supervisors write a letter by March 1st of each year which details the supervisor's evaluation of each graduate student's performance and progress toward a degree. Graduate students and faculty supervisors meet at an appropriate and convenient time to discuss the student's report and supervisor's

evaluation, concentrating most especially on any differences in expectations or evaluation between the student and supervisor. Both the student's report and supervisor's letter will become a part of the student's file. It is expected that advisory committee members will be used appropriately to develop each student's academic program, in the planning and execution of the research project, and in contributing to the evaluation letter. A form that serves to more clearly define guidelines and requirements is available. Briefly, students must be registered for the minimum of three credits in the semester/summer they take an examination or when a degree is completed. If a dissertation is ready for defense by the beginning of a semester (See http://www.grads.vt.edu/academics/dates_deadlines/commencement_deadlines.html for the deadlines for each semester of the current year) the student may qualify for Defending Student Status (DSS, 1 credit; http://www.grads.vt.edu/graduate_catalog/poli/UIPo.jsp?p=11). The department has created a Graduate Student Progress Check List and the Annual Graduate Student Evaluation Form. These are included at the end of this document. Time Limits for Degree Programs Guidelines for time to complete graduate degree programs are established as departmental policy in the interest of both the department and student. As a general guideline, it is expected that MS programs will be completed within two years and that Doctoral programs will require no more than three years. Students receiving financial assistance are assured of continuing support for these periods of time. In the event that circumstances prevent completion of a degree within the prescribed time limit, it is the responsibility of the student's faculty supervisor to request or provide an extension of financial support.

Annual Evaluation Guidelines There are two new forms that will become part of the student record in the department. The first is a DASC Graduate Student Checklist and the second is a DASC Annual Student Evaluation Form. Copies of these forms are also included at the end of this document. Copies of the forms (saved as word documents) are available on the Department website. The annual evaluation of graduate students provides an opportunity to insure that appropriate progress toward degree requirements is occurring and to allow for adjustments in the program of study, teaching activities, or research efforts. It is also important to keep the advisory committees informed. Evaluations occur in the Spring Semester (see above) - to meet pending graduate school requirements -- first evaluations may be brief. However, the following elements are expected to be part of the evaluation documentation as appropriate. Signatures of the Major Advisor and Committee Members (likely not applicable during your first evaluation cycle). Milestones accomplished - for example, filing of the program of study or scheduling of the preliminary exam (for a Ph.D. student). Documentation indicating that a regular meeting of the student advisory committee was held and a brief written summary of major conclusions from the meeting (may not apply with initial evaluations). List of publications. List of professional talks. Documentation of teaching activities. Listing of service activities. Awards and other honors. General academic progress - i.e. satisfactory progress in class work as well as research activities. Comments by the student Signature of Student - to indicate that her or she read and understands the document

PhD Degree

Offered In (Blacksburg)

TOEFL

Paper: Minimum (577.0)

Computer: Minimum (233.0)

iBT: Minimum (90.0)

GRE

Average Scores of Candidates: Verbal (150.0), Quantitative (165.0), Analytic Writing (3.5)

Graduate Advisory Committee All students are assigned a faculty supervisor (major professor) prior to, or immediately after initial enrollment. Assignments should be mutually agreeable to both student and faculty member, and each faculty supervisor should have an active research program in the area of student interest. Within the first or second semesters of enrollment, each student should work with his/her faculty supervisor to establish an advisory committee (three members for MS committees; four for Ph.D. committees) to assist in the development of a program of study and completion of the thesis or dissertation research project. Advisory Committee members are expected to provide appropriate and timely input to the academic and research programs of the student. Conversely, both students and faculty supervisors are expected to assure appropriate involvement of the advisory committees in each student's program. Students should discuss any problems related to their advisory committee with their faculty supervisor and, if needed, with the department head. Credit Hour Loads Full-time credit hour loads are 12 hours in Fall and Spring semesters (in addition to courses audited). Typically, students will register for 6 to 9 hours of formal course work (2 to 3 classes) during Fall and Spring terms (or less during the latter stages of a graduate program), and for sufficient hours of Research and Thesis (MS) or Research and Dissertation (PhD) credits to complete the 12-hour, full-time load. Note that this is required for payment of assistantships and for progression from assistantship step 1 to step 2, since step 2 requires the completion of 24 credit hours. Students who, prior to the beginning of a semester, will have 1) fulfilled all residency and course requirements 2) scheduled their final exam to take place by the Friday of the third week of classes and 3) submit a final thesis or dissertation to their committee during the first three weeks of the semester, are eligible to request registration for 1 hour as Start of Semester Defense Exception. A certification form, available from the departmental office, must be submitted to the Graduate School in order to be registered as Start of Semester Defense Exception. Registration may affect eligibility for assistantships and certain student benefits and/or loans since students so registered do not pay the comprehensive fee and are not classified as full-time students. Evaluation of Performance and Progress toward Degree In an effort to foster communications between graduate students, their faculty supervisors, and advisory committees, the Dairy Science Department requires an annual evaluation and communication of graduate student performance and progress toward either the M.S. or Ph.D. degree. The process is initiated with a written report, from each graduate student to his/her faculty supervisor, which appropriately details the graduate student's academic and research program progress during the preceding year. The form of the report is the prerogative of the faculty supervisor and due by February 1st of each year or earlier as designated by the faculty supervisor. In response, faculty supervisors write a letter by March 1st of each year which details the supervisor's evaluation of each graduate student's performance and progress toward a degree. Graduate students and faculty supervisors meet at an appropriate and convenient time to discuss the student's report and supervisor's evaluation, concentrating most especially on any differences in expectations or evaluation between the student and supervisor. Both the student's report and supervisor's letter will become a part of the student's file. It is expected that advisory committee members will be used appropriately to develop each student's academic program, in the planning and execution of the research project, and in contributing to the evaluation letter. A form that serves to more clearly define guidelines and requirements is available. Briefly, students must be registered for the minimum of three credits in the semester/summer they take an

examination or when a degree is completed. If a dissertation is ready for defense by the beginning of a semester (See http://www.grads.vt.edu/academics/dates_deadlines/commencement_deadlines.html for the deadlines for each semester of the current year) the student may qualify for Defending Student Status (DSS, 1 credit; http://www.grads.vt.edu/graduate_catalog/poli/UIPo.jsp?p=11). The department has created a Graduate Student Progress Check List and the Annual Graduate Student Evaluation Form. These are included at the end of this document. Time Limits for Degree Programs Guidelines for time to complete graduate degree programs are established as departmental policy in the interest of both the department and student. As a general guideline, it is expected that MS programs will be completed within two years and that Doctoral programs will require no more than three years. Students receiving financial assistance are assured of continuing support for these periods of time. In the event that circumstances prevent completion of a degree within the prescribed time limit, it is the responsibility of the student's faculty supervisor to request or provide an extension of financial support. Annual Evaluation Guidelines There are two new forms that will become part of the student record in the department. The first is a DASC Graduate Student Checklist and the second is a DASC Annual Student Evaluation Form. Copies of these forms are also included at the end of this document. Copies of the forms (saved as word documents) are available on the department website. The annual evaluation of graduate students provides an opportunity to insure that appropriate progress toward degree requirements is occurring and to allow for adjustments in the program of study, teaching activities, or research efforts. It is also important to keep the advisory committees informed. Evaluations occur in the Spring Semester (see above) to meet pending graduate school requirements -- first evaluations may be rather brief. However, the following elements are expected to be part of the evaluation documentation as appropriate. Signatures of the Major Advisor and Committee Members (likely not applicable during your first evaluation cycle). Milestones accomplished - for example, filing of the program of study or scheduling of the preliminary exam (for a Ph.D. student). Documentation indicating that a regular meeting of the student advisory committee was held and a brief written summary of major conclusions from the meeting (may not apply with initial evaluations). List of publications. List of professional talks. Documentation of teaching activities. Listing of service activities. Awards and other honors. General academic progress - i.e. satisfactory progress in class work as well as research activities. Comments by the student Signature of Student - to indicate that her or she read and understands the document

GRADUATE COURSES (DASC)

DASC 5004:

Seminar

Reports and discussion of current research in dairy science. Required of DaSc graduate students. May be repeated.

Credit Hour(s): 1

Lecture Hour(s): 1

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

DASC 5904:**Project and Report**

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Research, Online Research

Instruction Type(s): Research, Online Research

Prerequisite(s):

Corequisite(s):

DASC 5974:**Independent Study**

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Independent Study

Instruction Type(s): Independent Study

Prerequisite(s):

Corequisite(s):

DASC 5984:**Special Study**

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

DASC 5994:**Research and Thesis**

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research

Instruction Type(s): Research

Prerequisite(s):

Corequisite(s):

DASC 6274:**Critical Thinking in Bovine Physiology and Metabolism**

Framework for bovine physiology and metabolism research. Advanced examination of how gene products, nutrients, and other metabolites cooperatively influence bodily functions in cattle. Evaluation of experimental designs and analytic methods used in physiology and metabolism research. Application of critical thinking. Interpretation and

appraisal of physiological and metabolic data. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ENTOMOLOGY

Timothy Kring, Head

Emeriti Faculty: Carlyle Brewster; Richard Fell; Donald Mullins; Peter Schultz; Michael Weaver;

Professors: James Bergh; Timothy Kring; Thomas Kuhar; Dini Miller; Douglas Pfeiffer; Scott Salom; Igor Sharakhov;

Associate Professors: Sally Entrekini; Paul Marek; Sally Paulson;

Assistant Professors: Albert Auguste; Margaret Couvillon; Alejandro Del Pozo-Valdivia; Gillian Eastwood; Aaron Gross; Roger Schuerch; Maria Sharakhova; Sally Taylor; Chin-Cheng Yang;

Research Faculty: James Wilson;

General Contact: kshelor@vt.edu

Graduate Site: <https://www.ento.vt.edu/academic-programs/graduate.html>

The Department of Entomology provides professional expertise concerning arthropods to the commonwealth, the nation, and the world. This includes teaching, training, and advising undergraduate and graduate students; conducting basic and applied research on arthropods and the pathogens they vector; providing information about management of arthropods and the usefulness of beneficial arthropods available to clientele and the public; developing management strategies to control arthropod pests in Virginia; fostering development of entomological expertise at the state, national or at the The department has three major focus areas that includes: (1) Biomedical Research, with emphasis on insect genomics and urban/public health. This includes mosquito and tick biology and vector control as they affect urban and public health, and human and animal disease; (2) Natural/Agro Ecosystems Research, with emphasis on IPM/Biological Control of pest problems, and environmental monitoring and protection, and (3) Urban Entomology and Pesticide Safety Education.

SPECIAL FACILITIES

The Entomology Department is housed in Price Hall, Agnew Hall, Latham Hall and the Fralin Life Sciences Institute.

Price Hall

The Entomology Department is housed in Price Hall with additional on-campus laboratory facilities located in Agnew Hall, Latham Hall and the Fralin Life Sciences Institute. Insectary and green house facilities are

located both at on-campus and off-campus sites. Other laboratory and research facilities include: Dodson Urban Pest Management Laboratory and facilities at Prices Fork (Apiculture Laboratory, Pollination Ecology Laboratory, and Quarantine Laboratory). In addition, students and faculty have access to research facilities located at Kentland Farm in Blacksburg and at our Agricultural Experiment Stations located throughout the state.

DEGREES OFFERED

MSLFS Degree

Offered In (Blacksburg)

TOEFL

Paper: (550.0)

iBT: (80.0)

The Entomology Department offers a Master's in Life Sciences degree with concentration in Entomology (thesis or non-thesis/online), or a Doctorate in Entomology. The graduate program offers training in basic and applied entomology through a combination of graduate courses, research programs, and teaching experience. Masters of Science In the Life Sciences Degree (MSLFS)MS students must take at least one course in each of three core areas:(1) Biochemistry/Molecular and Cell Biology (Biochemistry for Life Sciences, Insect Physiology or Insecticide Toxicology); (2) Statistics (Biometry, Statistics in Research, or approved substitute); and (3) Information Management (Research and Information Systems in the Life Sciences). For the thesis-based MS, 20 credit hours of course work and 10 credit hours of research are required. For a non-thesis MS, a minimum of 30 credit hours of course work must be completed for graduation. With successful completion of both course work and research (thesis) requirements, MS students will receive a Masters of Science in the Life Sciences (MSLFS) with a Concentration in Entomology. Students in the Non-Thesis MSLFS Program are required to complete an internship and a project in addition to course work. The Non-Thesis MS student will complete the course requirements outlined in the Graduate Policies and Procedures and Course Catalog and those described above for MSLFS candidates in this department. They will have a Major Professor and Advisory Committee similar to those of other MSLFS candidates. The Advisory Committee will supervise the Plan of Study, the selection and conduct of the internship and project, and will conduct a Final Oral Examination. Note that a Non-Thesis Masters Degree is intended to be a terminal degree and is not a satisfactory prerequisite for continuing on toward a PhD. The department also participates in the college on-line MSALS degree program

PhD Degree

Offered In (Blacksburg)

TOEFL

Paper: (550.0)

iBT: (80.0)

Successful completion of a thesis-based MS in entomology or related field, OR significant experience in research as an undergraduate or in the workplace is required for admission to the PhD program. PhD students must take or have taken at least one course in each of three

core areas: (1) Biochemistry/Molecular and Cell Biology (Biochemistry for Life Sciences, Insect Physiology or Insecticide Toxicology); (2) Statistics (Biometry, Statistics in Research, or approved substitute); and (3) Information Management (Research and Information Systems in the Life Sciences). PhD students are expected to demonstrate competency in their area of specialization and are required to take a minimum of 27 hours of courses numbered 5000 or higher. Candidates for the PhD must demonstrate breadth of experience in at least one topic apart from the major area of study. This enrichment experience must be approved by the Advisory Committee and may take the form of foreign language, business, computer science or other pre-approved topic or concentration of courses in a selective area.

GRADUATE COURSES (ENT)

ENT 5004:

Graduate Seminar

Lectures and discussions by faculty and students on a current topic pertinent to research being conducted in the department. Critical evaluation of principles, theories, and methods will be emphasized. May be repeated.

Credit Hour(s): 1

Lecture Hour(s): 1

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ENT 5114:

Insect Structure and Function

A comparative study of the major structures and organ systems emphasizing modifications important in the success of insects. Designed for graduate and upper level undergraduate students in entomology and zoological biology.

Credit Hour(s): 0 OR 3

Lecture Hour(s): 0 OR 2

Instruction Type(s): Lab, Lecture, Online Lecture

Instruction Type(s): Lab, Lecture, Online Lecture

Prerequisite(s): ENT 3014

Corequisite(s):

ENT 5214:

Arthropod Pest Mgmt

Principles and techniques designed to reduce pest levels below those causing injury of economic importance to agriculture and forestry.

Course objectives are to provide students with background information which will enable them to formulate comprehensive approaches to pest problems and emphasize alternate methods of pest control and integrated approaches to pest problems. Appropriate for graduate

students in entomology, plant protection, and related curricula.

Credit Hour(s): 0 OR 3

Lecture Hour(s): 0 OR 2

Instruction Type(s): Lab, Lecture, Online Lecture

Instruction Type(s): Lab, Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ENT 5234:

Managing Arthropod Pests

Principles and techniques for reducing pests in agriculture and forestry.

Concepts of pest management to enable students to formulate comprehensive approaches to solving pest problems. Integrated pest management of primarily North American crops. Pre: Two semesters of biology or two years experience in agriculture production, industry or policy. Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ENT 5264:

Biological Control of Arthropod Pests and Weeds

Principles involved in the use of indigenous and introduced biological agents in the regulation of arthropod pests and weeds. Course objectives are to emphasize concepts important in biological control: population dynamics, host-parasite interactions, characteristics of parasitism and predation, principles involved in current biological approaches to pest control, and use of biological agents to control weeds. Suitable for students in entomology, plant protection, and related curricula.

Credit Hour(s): 0 OR 3

Lecture Hour(s): 0 OR 2

Instruction Type(s): Lab, Lecture, Online Lecture

Instruction Type(s): Lab, Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ENT 5324:

Genomics of Disease Vectors

An in-depth examination of the modern approaches and techniques currently employed to study genomes of arthropod vectors of human, animal, and plant diseases. Topics include: genome organization, regulation, and evolution; preparation and analysis of chromosomes; genome mapping, sequencing and assembly; principles of taxonomy

and systematics; adaptation and evolution of arthropod vectors; genetics of vector competence; comparative genomics and bioinformatics. Graduate standing required.

Credit Hour(s): 0 OR 2

Lecture Hour(s): 0 OR 1

Instruction Type(s): Lab, Lecture, Online Lecture

Instruction Type(s): Lab, Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ENT 5404:

Insect Evolution and Diversity

Examination of major evolutionary events of the arthropod tree of life, focusing on terrestrial arthropods with an emphasis on insects, millipedes, centipedes, arachnids (such as spiders, harvestmen, and scorpions) and close relatives. Review arthropod morphology. Identification of insect specimens to the species taxonomic level, and arthropods to class. Current approaches for taxonomy and how new species are named and classified. Building and curating an insect collection and best practices of natural history museums. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 2

Instruction Type(s): Lab, Lecture, VB, Online Lecture

Instruction Type(s): Lab, Lecture, VB, Online Lecture

Prerequisite(s): ENT 5114

Corequisite(s):

ENT 5624:

Animal and Plant Biosafety and Biosecurity

Principles, tools, and techniques of disease detection, early warning, and containment of animal and plant pathogens. Regulatory agencies and guidelines used to ensure the biosafety and biosecurity of the US food supply from accidental introductions and potential bioterrorism.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): ENT 5044

Corequisite(s):

ENT 5904:

Project and Report

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

523 Instruction Type(s): Research, Online Research

Instruction Type(s): Research, Online Research

Prerequisite(s):

Corequisite(s):

ENT 5974:

Independent Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Independent Study, VI

Instruction Type(s): Independent Study, VI

Prerequisite(s):

Corequisite(s):

ENT 5984:

Special Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 0 TO 10

Instruction Type(s): Lab, Lecture, Online Lecture

Instruction Type(s): Lab, Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ENT 5994:

Research and Thesis

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research, Online Research

Instruction Type(s): Research, Online Research

Prerequisite(s):

Corequisite(s):

ENT 6004:

Advanced Topics in Entomology

In depth presentations and discussions on selected advanced topics in entomology. (Maximum 4 C per course).

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ENT 6154:

Insect Physiology

Detailed study of the physiology and biochemistry of insect organ systems. Topics include: circulation, digestion, respiration, excretion, hormonal regulation, pheromones, intermediary metabolism, and nerve and muscle physiology. Laboratories provide exposure to instrumentation and techniques used in physiological research.

Credit Hour(s): 0 OR 4

Lecture Hour(s): 0 OR 3

Instruction Type(s): Lab, Lecture, Online Lecture

Instruction Type(s): Lab, Lecture, Online Lecture

Prerequisite(s): ENT 5114, CHEM 2535, CHEM 2536

Corequisite(s):

ENT 6164:

Insecticide Toxicology

Concepts and techniques of insecticide chemistry, toxicology, pharmacology, mechanism of action, metabolism, and resistance of small molecule insecticides. Biotechnology and pest management. Registration and renewal of insecticides. Non-target toxicity of insecticides (primarily to mammals). Environmental fate and risk assessment of insecticides. Pre: Graduate standing.

Credit Hour(s): 4

Lecture Hour(s): 3

Instruction Type(s): Lab, Lecture, VB, Online Lecture

Instruction Type(s): Lab, Lecture, VB, Online Lecture

Prerequisite(s): null null

Corequisite(s):

ENT 6354:

Insect Behavior and Ecology

Concepts, theory, and research techniques in insect behavior and ecology. General ecology including population, spatial, and community ecology; foraging behavior; communication systems; reproductive behavior and ecology; population regulation by natural enemies; social behavior; and population management using concepts of applied ecology.

Credit Hour(s): 4

Lecture Hour(s): 3

Instruction Type(s): Lab, Lecture, Online Lecture

Instruction Type(s): Lab, Lecture, Online Lecture

Prerequisite(s): ENT 5114

Corequisite(s):

ENT 6984:

Special Study

NONE

524 Credit Hour(s): 1 TO 19

Lecture Hour(s): 0 TO 10

Instruction Type(s): Lab, Lecture, Online Lecture

Instruction Type(s): Lab, Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

ENT 7994:

Research and Dissertation

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research, Online Research

Instruction Type(s): Research, Online Research

Prerequisite(s):

Corequisite(s):

FOOD SCIENCE AND TECHNOLOGY

Joseph Marcy, Head

Professors: Renee Boyer; Susan Duncan; Joseph Eifert; Joseph Marcy; Sean O'Keefe; Susan Sumner; Robert Williams;

Associate Professors: David Kuhn; Monica Ponder;

Assistant Professors: Haibo Huang; Jacob Lahne; Reza Ovissipour; Amanda Stewart; Laura Strawn;

Research Faculty: Elizabeth Chang; Melissa Chase; Joell Eifert; Brian Wiersema;

Assistant Professor of Practice: Herbert Bruce;

General Contact: fstinfo@vt.edu

Graduate Site: <https://www.fst.vt.edu/programs/graduate.html>

Food science and technology is a fusion of chemistry, microbiology and engineering. Our researchers explore innovation in the areas of creating new, healthful food products, and ensuring a safe and tasty food supply. Specific research emphases include: improving food nutrition, quality and flavor, developing novel functional food ingredients and products for promoting human health, packaging design and use of advanced technologies to identify and control food-borne disease causing organisms. Individual graduate programs are customized with the advisor to emphasize food safety/microbiology, biochemistry, food chemistry, or packaging. Student graduate programs are built around courses in microbiology, chemistry, biochemistry, biology, engineering, and statistics. This diverse curriculum prepares students for opportunities in industry, universities or government. Students who earn graduate degrees in Food Science and Technology at Virginia Tech have pursued careers with large food companies (Nestle, Campbell, Kroger, ConAgra, Hershey, etc.) and public health agencies (USDA, FDA, State Health and Agriculture Departments).

SPECIAL FACILITIES

The Department has research activity both on the Blacksburg campus and at two Agricultural Research and Extension Centers (AREC): the Seafood AREC in Hampton, Virginia and the Eastern Shore AREC (vegetable production, produce food safety) in Painter, Virginia. Research and teaching facilities on the Blacksburg campus are located in the Food Science and Technology Building and the Human & Agricultural Biosciences Building. These are further described below.

Food Science and Technology Building

The Department of Food Science and Technology is based in a separate 34,000 square-foot building which includes a 68-seat classroom and a variety of analytical instrumentation, equipment, and research-scale pilot plant facilities including: Food Analysis Laboratories, Microbiology Laboratories, Packaging and Processing Pilot Plant, Research Winery and Enology Laboratory, Sensory Evaluation Laboratory, Analytical Support Laboratory, and High Hydrostatic Pressure Processing Laboratory.

Human and Agricultural Biosciences Building Phase 1 (HABB1):

In 2014, the Department expanded into the new Human and Agricultural Biosciences Building 1 which houses research facilities for both the Food Science and Technology and the Biological Systems Engineering departments. The 93,860-square-foot building incorporates laboratory and support facilities, focusing on a wide range of microbiological and biochemical research. Researchers benefit from the expanded space which houses research programs on food safety, food packaging and processing, environmental quality analysis, bioenergy and biomaterials, systems biology, and nanotechnology, among other areas. This building includes the following: open workspaces and communal areas for faculty, students and industry to work collaboratively new research laboratories with shared equipment and laboratory support spaces consolidated in the core of the building a 7,100 square foot food processing pilot plant. a 2,200 square foot food safety pilot plant certified for use with biosafety level 2 human pathogens sensory evaluation laboratory complete with sensory data collection software, observational cameras and multi-option booth lighting, individual panelist booths, prep kitchens, and group debriefing and discussion rooms. offices for researchers and work spaces for graduate students.

DEGREES OFFERED

PhD Degree

Offered In (Blacksburg)

TOEFL

Paper: (550.0)

Computer: (213.0)

iBT: (90.0)

GRE

General Test: Verbal - preferred score (151.0), Quantitative - preferred score (153.0), Writing - preferred score (3.5)

A Masters degree is expected for students applying to the doctoral program. In exceptional cases, some students with only a Bachelors degree may be considered for a doctoral program. Students who do not have academic training equivalent to that required for a B.S. degree in Food Science and Technology at Virginia Tech will complete selected core courses before graduation. Students without a background in a science related field may be required to complete supplemental courses before being admitted to a regular student status. Any supplemental course work recommended by the Graduate Committee will be communicated to the applicant in a letter.

MSLFS Degree

Offered In (Blacksburg)

TOEFL

Paper: (550.0)

iBT: (90.0)

Computer: (213.0)

GRE

General: Verbal - preferred score (151.0), Quantitative - preferred score (153.0), Writing - preferred score (3.5)

Students who do not have academic training equivalent to that required for a B.S. degree in Food Science and Technology at Virginia Tech will complete selected core courses before graduation. Students without a background in a science related field may be required to complete supplemental courses before being admitted to a regular student status. Any supplemental course work recommended by the Graduate Committee will be communicated to the applicant in a letter.

GRADUATE COURSES (FST)

FST 5004:

Graduate Seminar

Special topics, critical reviews, and discussions of current literature throughout a wide range of subject areas in food science and technology. May be repeated.

Credit Hour(s): 1

Lecture Hour(s): 1

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

FST 5014:

Sensory Evaluation of Food

Principles of sensory evaluation including experimental methods, applications, and statistical analyses.

Credit Hour(s): 0 OR 3

Lecture Hour(s): 0 OR 2

Instruction Type(s): Lab, Lecture, Online Lecture

Instruction Type(s): Lab, Lecture, Online Lecture

Prerequisite(s): STAT 2004 OR FST 4524)

Corequisite(s):

FST 5034:

Good Agricultural and Manufacturing Practices

Principles of food safety management for food producing and food processing environments. Emphasis on guidelines developed in Good Agricultural Practices for plant-based foods and Current Good Manufacturing Practices. Pre: Academic and/or professional background in food processing, quality assurance, fresh produce production, food product regulation, and/or food safety. Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

FST 5044:

Global Food Laws and Regulations

History of laws and regulations that affect the food processing industry and food consumers. Impact of legal and regulatory issues on food quality, safety, formulation, labeling, marketing, grading, product and process development, and international trade for the U.S. and other nations. Pre: Academic and/or professional background in food processing, quality assurance, and/or food safety.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

FST 5054:

Professionalism in Food Scienc

Applied principles and skills in communication, research ethics and research project design for the food science profession. Pre: Graduate standing. P/F only.

Credit Hour(s): 1

Lecture Hour(s): 1

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

FST 5094 (BMVS 5094) (CHEM 5094):**Grant Writing and Ethics**

A framework for writing clear, concise grant proposals in a team-oriented, multidisciplinary approach from concept development through submission to a funding agency. Potential ethical dilemmas that may arise in academic, industrial, or federal research settings will be discussed. PRE: Undergraduate courses in one of the following: organic chemistry (CHEM 2565/2566), cell & molecular biology (BIOL 2104), Concepts of Biochemistry (BCHM 2024), or equivalent. Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

FST 5174:**Total Life Cycle Risk Management for Health Products**

Application of risk management principles integrated with systems engineering concepts to product, process and support life cycles and the iterative feedback loops of information for continuous improvement to reduce risk. Design and analysis of creating a risk management system for health product manufacturers. Initiation of an integrated risk management system into the corporate environment and application of appropriate information technologies to integrate various system elements to provide an enterprise solution. Managing health product risks at product conception and thereafter.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): FST 5134, FST 5144

Corequisite(s):

FST 5404:**Food Packaging**

Examines the role of food packaging in the preservation of foods in today's society. Food packaging materials will be discussed with emphasis on their interaction with food products. Specific applications of packaging materials to food groups will be discussed. Procedures to develop a new food package are incorporated in class activities.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): FST 4405

Corequisite(s):

FST 5604:**Advances in Food Microbiology**

Critical review of current topics in food microbiology. Foodborne pathogens, toxins, analytical methodology, food spoilage, inhibition and destruction of bacteria, standards, and fermentations.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): FST 4604, BCHM 5124

Corequisite(s):

FST 5614:**Food Safety and Security**

Identification and prevention of food safety and security hazards that may result in intentional or unintentional contamination. Development and implementation of plans to enhance food safety and security in the processing, distribution, transportation, and retail segments of the food supply chain. Pre: Academic and/or professional background in food processing, quality assurance, and/or food safety. Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

FST 5624:**Applied Food Microbiology and Sanitation**

Overview of the causes, transmission, and epidemiology of major environmental, food-, and water-borne diseases in the food industry. Detection, monitoring, and control of important environmental pathogens. Chemical, physical, and biological sanitation to control pathogens in food, water, and the environment. Pre: Academic and/or professional background in microbiology, food safety, or environmental health. Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

Adv Epi Food & Water Diseases

Overview of causes, transmission, and epidemiology of major environmental, food, and waterborne diseases. Outbreak and sporadic detection, source tracking, and control of pathogens. Overview of the impact of food-borne outbreaks on regulatory activities at the national and international level. Prerequisite: Graduate Standing required

Credit Hour(s): 4

Lecture Hour(s): 4

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

FST 5664:

Flavor Chemistry

Study of flavor compounds, their isolation, extraction, and flavor profiles. Examination of compounds that are used to produce commercial flavors from synthetic and natural sources. Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): FST 4504, FST 4514

Corequisite(s):

FST 5904:

Project and Report

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research, Online Lecture, Online Research

Instruction Type(s): Research, Online Lecture, Online Research

Prerequisite(s):

Corequisite(s):

FST 5974:

Independent Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Independent Study, VI

Instruction Type(s): Independent Study, VI

Prerequisite(s):

Corequisite(s):

FST 5984:

Special Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

FST 5994:

Research and Thesis

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research

Instruction Type(s): Research

Prerequisite(s):

Corequisite(s):

FST 7994:

Research and Dissertation

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research

Instruction Type(s): Research

Prerequisite(s):

Corequisite(s):

HORTICULTURE

Michael Evans, Head

Emeriti Faculty: Richard Veilleux;

Professors: Eric Beers; Joyce Latimer; Alexander Niemiera; Gregory Welbaum; Anthony Wolf;

Associate Professors: Susan Clark; Megan O'Rourke; Mark Williams; Bingyu Zhao;

Assistant Professors: Bastiaan Bargmann; Jayesh Samtani; Sherif Sherif;

Affiliated Faculty: James Altland; Kedong Da; Laurie Fox; Alex Hessler; Zongrang Liu; Amber Vallotton;

Graduate Contact: spesgradinfo@vt.edu

Graduate Site: <https://spes.vt.edu/>

The Horticulture graduate program in the School of Plant and Environmental Sciences offers programs leading to the Master's and

Doctoral degrees. Areas of specialization include: plant breeding and genetics growth and development physiology molecular biology intensification of production through modern cultural practices and innovative approaches urban horticulture rhizosphere biology agricultural ecology The faculty are stationed both on campus in Blacksburg and at several experiment stations throughout the state. Although not all faculty serve directly as advisors to graduate students, all are available as resources to graduate programs. Note: The MS in Horticulture is available through Agriculture and Life Sciences. Students apply to the MSLFS degree type and select Horticulture as the program.

SPECIAL FACILITIES

On Campus Modern research facilities and several offices are housed in Latham Hall. Offices, a 25-station computer lab, and several classrooms are housed in Saunders Hall. Greenhouse space assigned to the department in the campus greenhouse complex exceeds 20,000 sq. ft. Field research may be conducted at the 10-acre Urban Horticulture Center near campus, at the nearby 1,700 acre Kentland Farm with orchards, vegetable and small fruit plots or at the agricultural experiment stations. The Hahn Horticulture Gardens and Pavilion is an extensively managed six-acre site on campus that supports some of our teaching and outreach effort. Off Campus Faculty are also located at three agriculture research and extension centers (AREC) across the state. The Alson H. Smith, Jr. AREC is located in Winchester where its programs are focused on tree fruit and grapes. The Hampton Roads AREC in Virginia Beach focuses on green industry (nursery and landscape) and small fruit crops research and outreach. The Eastern Shore AREC where Horticulture faculty are located in Painter, on the Eastern shore of Virginia, focuses on vegetable research.

Hahn Horticulture Garden

The Hahn Horticulture Garden encompasses nearly six acres of teaching and display gardens on the campus of Virginia Tech in Blacksburg, Virginia. Established in 1984 by Horticulture faculty, the garden serves undergraduate students and the local community as a learning resource for plant material, landscaping concepts, and environmental awareness.

Kentland Farm

Kentland farm is utilized for research and teaching purposes by faculty members in the College of Agriculture and Life Sciences and by 12 departments in other colleges at Virginia Tech.

Latham Hall

Faculty in the School of Plant and Environmental Sciences are working in Latham Hall to improve human health and nutrition, sustain the environment, and develop resilient and productive cropping systems. Extensive resources for breeding, genetics, physiology, biochemistry, molecular biology, microbiology, plant pathology, microscopy, metabolomics, genomics, tissue culture, plant transgenesis, bioinformatics, and controlled environment experiments are available for graduate research in Latham Hall.

Saunders Hall

Five research and teaching laboratories are located in Saunders Hall including agricultural ecology, plant nutrition, ornamentals research, and the Powerland phenotyping facility.

Virginia Tech Greenhouses

Virginia Tech's main greenhouse range is located on the corner of Washington Street and Garden Lane, in-between the Hahn Horticulture Garden and McComas Hall. Many departments and programs utilize the greenhouses 51,000 square feet of space for teaching, research and extension activities. Ten wings of glass houses are joined by a central corridor, and eight self-contained fiberglass, polyethylene or polycarbonate houses supplement the main range.

DEGREES OFFERED

PhD Degree

Offered In (Blacksburg)

TOEFL

Paper: (550.0)

Computer: (213.0)

iBT: (90.0)

GRE

General: Verbal (150.0), Quantitative (150.0), Analytical (4.0)

Minimum Course Requirements for PhD (includes courses accepted by advisory committee from MS); advisory committee may require additional 12 - HORT, CSES, PPWS, BIOL, BCHM, FOR, ENT (5000-6000 level only) 6 - Advanced statistics (STAT) 1 - Research Ethics in Agriculture and Life Sciences (ALS 5324) 1 - Professional Communication in Ag. and Life Sciences (ALS 5334) 2 - Horticulture Seminar (HORT 5004) MINIMUM CLASSROOM REQUIREMENT = 22*30-70 Research and Dissertation (HORT 7994) TOTAL CREDIT HOURS REQUIRED = 90*Independent study not applicable; 5000-6000 classes only. Maximum of 11 classroom credit hours can be transferred from a non-VT program. An oral and written preliminary exam and a successful defense of a dissertation are also required.

MS Degree

Offered In (Blacksburg)

TOEFL

Paper: (550.0)

Computer: (213.0)

iBT: (90.0)

GRE

General Test: Verbal (150.0), Quantitative (150.0), Analytical (4.0)

The MS in Horticulture is available through Agriculture and Life Sciences. Students should apply by selecting Horticulture as the Program and MSLFS as the Degree Type. All MS students, unless enrolled in the On-Line program, are expected to complete a thesis. Course requirements for the MS degree include: ALS 5324: Research Ethics in Agriculture and Life Sciences ALS 5334: Professional Communication in Agriculture and Life Sciences HORT 5004: Horticulture Seminar 9 credits in graduate level HORT, CSES, PPWS, BIOL, BCHM, FOR, ENT 3 credits in Statistics HORT 5994: Research and dissertation, 6-10 credits 30 credits total Students interested in the On-Line Masters with emphasis in Horticulture are directed to the OMALS website.

GRADUATE COURSES (HORT)

HORT 5064G:

Advanced Soil Microbiology

Soil microbes as determinants of plant growth, sustainable agricultural systems, and global nutrient cycles. Environmental controls of soil microbes and relationship to soil decomposition. Soil as a micro-habitat. Application to soil management and plant growth, plant-microbe mutualisms, probiotics, biocontrol, composting, ecosystem restoration, and disease suppression. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

HORT 5304:

Advanced Plant Genetics and Breeding

Plant breeding theory and methodology for the improvement of agronomic and horticultural crops; genetic diversity; polyploidy; gene inheritance, expression, interaction, and stability; incompatibility; male sterility; haploidy; genetic engineering and transformation; parental selection, hybridization, and population development; breeding methods, genotypic and phenotypic selection and evaluation; strategies for cultivar development including marker assisted selection and breeding for durable disease resistance. Graduate standing required.

Credit Hour(s): 4

Lecture Hour(s): 3

Instruction Type(s): Lab, Lecture, Online Lecture

Instruction Type(s): Lab, Lecture, Online Lecture

Prerequisite(s): BIOL 2004 (UG) OR BIOL 2004 OR CSES 4144 (UG)

OR CSES 4144

Corequisite(s):

HORT 5474:

Adv Stud in Urban For Ecosys

The nature and dynamics of urban ecosystems with emphasis on the role of urban forests. Examines the interactions of urban forests with the built environment at multiple scales and from multiple disciplinary perspectives. Management influence on ecosystem processes and approaches to estimating urban forest ecosystem services from urban cores to pre-urban development. Pre-requisite: Graduate Standing required

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

HORT 5514:

Plant Nutrition

Fundamentals of plant nutrient availability, uptake, assimilation, transport, function, and deficiencies. Influence of plant root environment and root physiology on plant nutrient status and subsequent effect on plant growth, crop yield, and relationship to plant diseases and pests.

Pre: Graduate Standing

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

HORT 5524 (PPWS 5524):

Advanced Plant Physiology and Metabolism I

Plant metabolism and its regulation, cell and organ structure and function. Current understanding of photosynthesis, respiration, nitrogen fixation, mineral nutrition, water and ion transport in plant cells and tissues, ecophysiology and responses of plants to the environment. Pre: undergraduate major in Biology or related discipline.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

HORT 5534:

Advanced Plant Physiology and Metabolism II

Presentation of the current understanding of metabolic and functional relationships among primary and secondary metabolites and storage products and their impact on the whole plant. Biosynthesis of phytohormones. Mechanisms controlling responses to phytohormones including: impact on carbon/nitrogen partitioning, senescence, development of higher plant structures such as vascular tissue and flowers. PRE: undergraduate major in Biology or related discipline.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

HORT 5764G:

Advanced Vegetable Crops

Advanced topics in vegetable production, post-harvest handling, economic importance, nutritional value, organic standards, consumption, biotechnology. Prerequisite: Graduate Standing required

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

HORT 5974:

Independent Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Independent Study, VI

Instruction Type(s): Independent Study, VI

Prerequisite(s):

Corequisite(s):

HORT 5784G:

Advanced Vegetable Seeds

Study of vegetable seed production focusing on pollination biology, molecular assessment of seed biology, and current research on seed biology. Seed production, handling, identification, conditioning, enhancement, packaging, storage, testing, federal standards, and biotechnology.

Credit Hour(s): 2

Lecture Hour(s): 2

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): HORT 5764G

Corequisite(s):

HORT 5984:

Special Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

HORT 5994:

Research and Thesis

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research, Online Research

Instruction Type(s): Research, Online Research

Prerequisite(s):

Corequisite(s):

HORT 5904:

Project and Report

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research, Online Research

Instruction Type(s): Research, Online Research

Prerequisite(s):

Corequisite(s):

HORT 7994:

Research and Dissertation

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research, Online Research

Instruction Type(s): Research, Online Research

Prerequisite(s):

Corequisite(s):

HORT 5914:

Ecology of Plant-Microbial Interactions

Diversity, structure and function of microorganisms and how they interact with plants at the root-soil interface. Plant-microbial interactions as drivers of global biosphere and sustainability of unmanaged and managed ecosystems.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

HUMAN NUTRITION, FOODS, AND EXERCISE

Stella Volpe, Head

Professors: Brenda Davy; Kevin Davy; Matthew Hulver; Dongmin Liu; Elena Serrano; Stella Volpe; Jay Williams;

Associate Professors: Deborah Good; Robert Grange; Samantha Harden; Young Ju; Dawnine Larson-Meyer; Eva Schmelz;

Assistant Professors: Siobhan Craige; Alexandra DiFeliceantonio; Joshua Drake; Valisa Hedrick; Vivica Kraak; Carlin Rafie; So Ra Shin; Jeffrey Stein;

Collegiate Associate Professors: Madlyn Frisard;

Research Assistant Professors: Sarah Misyak;

HNFE Graduate Program: hnfegrads@vt.edu

HNFE Graduate website: <http://hnfe.vt.edu/programs/graduate.html>

Our mission is to discover, translate, and disseminate health-related advances in the nutrition, food, and exercise sciences. The work of the faculty and graduate students in the Department of Human Nutrition, Foods and Exercise (HNFE) contributes significantly to scientific progress through molecular and clinical advances leading to prevention and improved treatment of obesity and chronic diseases; behavioral discoveries that lead to effective intervention programs for youth and adults; and interdisciplinary research teams who speed the translation of scientific discoveries to effective therapeutic and public health interventions that will benefit Virginians and the nation. We provide exceptional training for our students focusing on the preparation of future professionals who are knowledgeable, committed to life-long learning, ethical, culturally sensitive, and able to work collaboratively as well as independently. Training in the use of rigorous scientific inquiry is the cornerstone of the HNFE graduate program. We foster innovation across all three Virginia Tech missions areas - teaching, research, and outreach - by (1) supporting programs that promote sustainability and community viability and encouraging student participation in research and extension; (2) designing, developing, and implementing programs and policies through a participatory and shared effort between the HNFE research and teaching community; and (3) utilizing our teaching and research expertise to improve the health across diverse populations. Finally, the department's main focus is on addressing one of the most critical public health challenges of today - chronic disease.

SPECIAL FACILITIES

The Department of Human Nutrition, Foods and Exercise is just one facet of a large and vibrant life science research enterprise at Virginia Tech. Our faculty study a range of health issues using cutting edge research equipment and facilities. Laboratory facilities available to support graduate student research include: molecular nutrition laboratories, muscle function and metabolism laboratories, small animal care facilities, a clinical research laboratory including a comprehensive body composition laboratory and an exercise-testing laboratory, a metabolic kitchen, two foods laboratories including a sensory evaluation facility, and the implementation and systems science laboratory. The Department also places considerable effort on generating and disseminating research findings. HNFE faculty are intimately involved in two Interdisciplinary Graduate Education Programs (IGEP) with the goal of promoting and sustaining interdisciplinary graduate education and research at Virginia Tech. The Translational Obesity Research IGEP is drawing faculty and students from diverse disciplines together to form integrative research teams with a central focus on translational obesity

research, spanning from "cells to society" (i.e., from basic science to practice, policy and practice implementation; or type 1 to 4 research translation). Faculty and graduate students from the departments of HNFE, Agricultural and Applied Economics, Communication, Human Development, and Psychology are working together to cross traditional boundaries and conduct innovative translational obesity research. The Water INTERface IGEP spans Engineering, Science, and Human Health, and is united by a central focus of "Water for Health", spanning from "pipes to people". This IGEP includes graduate students and faculty from HNFE, Food Science and Technology, Biological Sciences, and Civil and Environmental Engineering to address technical and societal challenges of transforming low-quality water resources into clean water for healthy living, and to promote water consumption for optimal health. The HNFE faculty enjoys strong collegial relationships with individuals of similar interests in other departments within the College of Agriculture and Life Sciences, such as the Biochemistry, Animal and Poultry Sciences, Food Science and Technology, as well as departments from the Colleges of Veterinary Medicine, Science, and Liberal Arts and Human Sciences. HNFE also collaborates with the Virginia Tech Carilion School of Medicine, the Virginia Tech Carilion Research Institute, and Carilion Clinic Departments of Pediatrics, Family Medicine, and Research. There are strong ties with the Student Health Center, statewide and national food and nutrition programs, and community agencies and health care facilities in the Blacksburg, Roanoke, and surrounding areas. The department faculty members are committed to the individual mentoring of each student. A faculty member usually has no more than four to six graduate students, allowing time for careful attention to each. Students also get to know faculty and other graduate students who serve as informal mentors through graduate classes and attendance at department seminars or other informal research presentations. HNFE's partnership with Virginia Tech Carilion Research Institute and Carilion Clinic has resulted in the Center for Transformative Research on Health Behaviors located at Fralin Biomedical Research Institute in Roanoke, conducts transformative health behaviors research with the primary objectives of prevention and treatment of lifestyle related disease.

Facilities

The Department of Human Nutrition, Foods, and Exercise (<https://www.hnfe.vt.edu/>) occupies space in Wallace Hall, War Memorial Hall, the Integrated Life Sciences Building at the Corporate Research Center, and the Fralin Biomedical Research Institute in Roanoke. Wallace Hall contains The Laboratory for Eating Behaviors and Weight Management, The Dietary Assessment laboratory, and the Metabolic Kitchen. The Food and Nutrition Policy Group is also located in Wallace Hall. The Integrated Life Sciences Building (ILSB) houses researchers from diverse backgrounds including, but not limited to, virology, biology, nutritional biochemistry, genetics, foods science, and behavioral science. The Molecular Nutrition, Muscle Function, and Muscle Metabolism laboratories can be found here as well as groups working on the molecular aspects of health, nutrition, and disease, including genetic determinants of obesity and the prevention of cancer, diabetes, and hypertension. This research is performed in laboratories equipped with modern molecular and cell biology instruments and tools for cellular and animal research. The building also houses equipment for the metabolic phenotyping core that allows for determination of body composition,

whole body energy metabolism, glucose and insulin tolerance, analysis of metabolites, and more. Furthermore, core facilities for quantitative real-time PCR, cell culture, radio-labeled substrate metabolism, mitochondrial function, histology, confocal microscopy, and flow cytometry are also located in the building. Center for Transformative Research on Health Behaviors (<https://ctrhb.vtc.vt.edu/>) located in VT Riverside in Roanoke conducts transformative health behaviors research with the primary objectives of prevention and treatment of life-style related diseases. Fralin Biomedical Research Institute in Roanoke houses additional space for clinical and behavioral scientists for clinical and community research. The space includes equipment to assess body composition, energy metabolism, and other clinical assessments. There is also space for conducting clinical and community based interventions and programs. War Memorial Hall houses The Human Integrative Physiology laboratory and provides the infrastructure for clinical studies requiring measurements of cardiovascular structure and function, submaximal and maximal exercise performance, body composition (DEXA), resting and exercise energy expenditure and substrate metabolism, and collection and processing of tissue and blood samples.

DEGREES OFFERED

MS Degree

Offered In (Blacksburg)

TOEFL

iBT: Total (90.0), Listening Subsection (20.0), Writing Subsection (20.0), Speaking Subsection (20.0), Reading Subsection (20.0)

IELTS (International English Language Testing System)

IELTS: Total (6.5)

The Department of Human Nutrition, Foods and Exercise offers a thesis-based Master's degree in one of three focus areas: Molecular and Cellular Science, Clinical Physiology and Metabolism, and Behavioral and Community Science. The minimum requirements for the MS degree are 30 graduate credit hours of which at least 20 credit hours must be graded course work (12 credit hours of 5000-level or higher) and at least 6 credit hours must be thesis research. The Department requires MS students to complete Translational Science in Human Nutrition, Foods and Exercise (HNFE 5204) and 3 credit hours of statistics. Students are also required to complete Ethics and Integrity and Diversity and Inclusion Training. See departmental website for more information.

<https://www.hnfe.vt.edu/programs/graduate.html> Accelerated Undergraduate/Graduate Degree (BS/MS) Seniors in a Virginia Tech bachelor's degree program, who have a GPA of 3.4 or better, may be eligible for an Accelerated Master's Degree in HNFE. Students must apply to the Graduate School for a Master's degree and submit the Accelerated Undergraduate/Graduate Degree and Course Designation Form to the Graduate School before the start of their senior year. The minimum requirements for the BS/ MS degree are the same as the Master's degree and 30 graduate credits of which at least 20 credits must be graded course work (12 credits of 5000-level or higher) and at least 6 credits must be thesis research credit hours. The Department

requires MS students to complete Translational Science in Human Nutrition, Foods and Exercise (HNFE 5204) and 3 credit hours of statistics. Students are also required to complete Ethics and Integrity and Diversity and Inclusion Training. See departmental website for more information. Students in this program may also apply for Dual Status during the final year of their undergraduate degree program. This allows students to obtain graduate credit during their senior year. See departmental website for more information.

<https://www.hnfe.vt.edu/programs/graduate.html>

PhD Degree

Offered In (Blacksburg)

TOEFL

iBT: Total (90.0), Listening Subsection (20.0), Writing Subsection (20.0), Reading Subsection (20.0), Speaking Subsection (20.0)

IELTS (International English Language Testing System)

IELTS: Total (6.5)

The Department of Human Nutrition, Foods and Exercise offers doctoral degrees in one of three focus areas: Molecular and Cellular Science, Clinical Physiology and Metabolism, and Behavioral and Community Science. The minimal requirements for the doctoral degree are 90 graduate credit hours of which at least 27 credit hours are based on graded course work (21 credit hours of 5000-level or higher) and at least 30 credit hours of dissertation research. The Department requires PhD students to complete Translational Science in Human Nutrition, Foods and Exercise (HNFE 5204) and 6 credit hours of statistics. Students are also required to complete Ethics and Integrity and Diversity and Inclusion Training. See departmental website for more information.

<https://www.hnfe.vt.edu/programs/graduate.html>

GRADUATE COURSES (HNFE)

HNFE 5044:

Seminar in Human Nutrition and Foods

Critical review and oral reporting of pertinent literature and research in the various areas of foods and nutrition.

Credit Hour(s): 1

Lecture Hour(s): 1

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

HNFE 5114G:

Advanced Food and Nutritional Toxicology

Principles of food and nutritional toxicology with primary emphasis on food components and food toxins including absorption, metabolism and excretion. An overview of types of adverse food reactions including food allergy, food sensitivity, and food intolerance. An overview of U.S. and international laws and regulation of safety assessment of foods including

food additives, dietary supplements, and residues of contaminants, pesticides, and antibiotics. Analysis of food and nutritional toxicity cases in the context of the food system, regulatory policies, and public communication. Pre: Graduate standing

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

HNFE 5125G:

Adv Medical Nutrition Therapy

Study of nutritional diagnostic, therapeutic and counseling services provided by a registered dietitian. Emphasis on the relationship between principles of nutritional care and the medical treatment of individuals with selected diseases or clinical problems. Pre-requisite: Graduate Standing required

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

HNFE 5126G:

Adv Medical Nutrition Therapy

Study of nutritional diagnostic, therapeutic and counseling services provided by a registered dietitian. Integration of knowledge of pathophysiology, biochemical, and clinical parameters, medical treatment and nutrition therapy for patients with selected clinical problems/disease states.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): HNFE 5125G

Corequisite(s):

HNFE 5144:

Molecular Aspects of Nutrition and Disease

The role of specific nutrients in human and animal health at a physiologic and molecular level. Emphasis is placed on the influence of nutrients on gene expression especially with regard to pathophysiology of diseases.

Physiological and molecular aspects of nutrition and immune function will also be discussed.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): BCHM 5124, (ALS 5104 OR HNFE 5104)

Corequisite(s):

HNFE 5154:

Research Methods in Nutrition and Physical Activity

Research evaluation and design for clinical and behavioral research with an emphasis on diet and physical activity assessment and intervention. Methods applicable to studies designed to test interventions, programs, and practices that target the end result of dietary and physical activity behavior change are emphasized. Research ethics. Pre: Graduate Standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

HNFE 5164:

Molecular Aspects of Diet and Cancer

Molecular and genetic/epigenetic factors in human cancer development. Cellular and molecular targets of the diet or specific nutrients in cancer prevention. Interaction of diet, obesity, and body weight on cancer. Dietary strategies targeting the tumor microenvironment and systemic contributors to tumor progression. Pre: Graduate Standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

HNFE 5174:

Nutrition for Sport & Exercise

Nutritional requirements for the well-being and optimal performance of athletes of various ages and for various sports. Methods of assessment and modification of diet, energy expenditure, performance, and body composition in athletes. Nutritional strategies for athletes based on sport and goals. Evaluation of ergogenic aids and dietary supplements for performance and body composition. Pre: Graduate Standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

HNFE 5174G:

Advanced Nutrition and Physical Performance

Nutritional requirements for the well-being and optimal performance of athletes. Methods of assessment and modification of diet, performance, and body composition in athletes. Evaluation of dietary ergogenic aids and supplements for performance and body composition. Pre: Graduate Standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

HNFE 5204:

Translational Science in HNFE

Principles and practice of translational science research as it relates to human health and chronic disease. Overview of basic science research, preclinical and clinical intervention development, and community and public health practice in relation to human nutrition, foods, and exercise. Principles of scientific inquiry from a team-based approach. Scientific team development and generation of interdisciplinary and translational research questions. Pre: Graduate Standing.

Credit Hour(s): 4

Lecture Hour(s): 4

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

HNFE 5214:

Physical Activity and Health

Practical applications of interventions for health promotion, disease prevention, and treatment in diverse adult populations. Implications of sedentary behavior. Physiological adaptations to exercise and physical activity, and fitness training principles. Exercise is Medicine initiative principles and health behavior change theories. Health assessment, exercise testing, and prescription. Historical evaluation and application of guidelines for healthy and diseased populations. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s): null null

HNFE 5304:

Principles of Dietetics and Nutrition Practice

Orientation to the Registered Dietitian Nutritionist (RDN) profession. Diverse practice roles and resources to support professional development. Introduction and assessment of concepts key to successful practice as an RDN (leadership strengths, continued professional development planning, code of ethics, standards of practice, effective communication and nutrition informatics). Strategies to influence the profession, the workplace and current food and nutrition policy issues. Pre: Graduate Standing.

Credit Hour(s): 2

Lecture Hour(s): 2

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

HNFE 5314:

Business of Dietetics and Healthcare

Business and management skills and perspectives for Registered Dietitian Nutritionists. Private practice and entrepreneurial strategies in nutrition and dietetics. Public relations messaging. Healthcare administration, federal and state regulations, and policy and impact on the dietetics profession. Pre: Graduate Standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

HNFE 5324:

Public Health Nutrition Policies and Programs

Public health, health promotion, food and nutrition policy and population-based nutrition principles in the United States (U.S.) and globally. Factors that contribute to nutrition-related health disparities and chronic diseases. Community and population-based nutrition assessment for vulnerable populations. Food policy and program development, implementation, monitoring and evaluation to promote healthy, resilient and sustainable food environments. Pre: Graduate Standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

HNFE 5334:

Clinical Nutrition Care Applications

Application of the nutrition care process including patient screening and clinical assessment (patient interviewing, anthropometrics measurements, nutrition-focused physical exam, energy and nutrient needs, laboratory values and other diagnostic tests, physical activity).

Consideration of assessments implication on development nutritional diagnosis and individualized intervention plan. Monitoring and evaluating impact of nutritional care. Exposure to diverse patient types using case-based, simulation and other experiential learning. Effective communication of nutrition care plan to healthcare team members.

Credit Hour(s): 2

Lecture Hour(s): 1

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): HNFE 5126G

Corequisite(s):

HNFE 5344:

Nutrition Counseling for Behavior Change

Practical application of behavior change theories, counseling techniques, and communication skills for nutrition-related behavior change of individuals and groups. Application of self-evaluation, quality improvement, and professional code of ethics. Counseling practice based on nutrition care process, evidence-based practices, counseling ethics, client-centered approaches, health literacy, and cultural competence. Effective communication in a counseling setting. Interdisciplinary teamwork for refining counseling skills and client outcomes. (2H, 3L, 3C)

Credit Hour(s): 3

Lecture Hour(s): 2

Instruction Type(s): Lab, Lecture, VB, Online Lecture

Instruction Type(s): Lab, Lecture, VB, Online Lecture

Prerequisite(s): EDCO 5214

Corequisite(s): HNFE 5126G

HNFE 5354:

Food for Optimal Health

Diet and menu planning and management logistics for Registered Dietitian Nutritionists to support health and disease management for diverse populations. Application of food safety principles and methods of microbial control while managing the flow of food in health-care, non-profit, and research environments. Recipe, menu, and diet design, analysis, and production based on principles of food chemistry, human health, federal regulation of food, globalized agricultural processes, and

environmental sustainability. Translation of food for health messages to target audiences.

Credit Hour(s): 3

Lecture Hour(s): 2

Instruction Type(s): Lab, Lecture, VB, Online Lecture

Instruction Type(s): Lab, Lecture, VB, Online Lecture

Prerequisite(s): HNFE 5126G

Corequisite(s):

HNFE 5364:

Sports Nutrition Applications

Applied sports nutrition tools and strategies. Practical evaluation and consumer education of sports foods and beverages, sports nutrition tools, and dietary trends. Evidence-based practice for working with special athlete populations and those exercising in extreme environments, conditions, and sports. Sports medical nutrition therapy.

Credit Hour(s): 3

Lecture Hour(s): 2

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): HNFE 5174G

Corequisite(s): HNFE 5126G

HNFE 5374:

Sports Nutrition Practicum

Practical sports nutrition work in a community setting. Experiential sports nutrition education and counseling with a focus on enhancing performance, health, and well-being. Ethics, regulations, legislation, and standards of professional practice in sports nutrition planning, care, and programs.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): HNFE 5174G

Corequisite(s):

HNFE 5384:

Research Dietetics Practicum

Application of research concepts and guidelines to practical work in nutrition-related research analysis and interpretation. Experiential research project development, implementation, and evaluation. Analyze and interpret research data. Protocol development and project quality control. Standards of professionalism and ethical research practice in nutrition research. Self-evaluation of practicum activities.

Credit Hour(s): 4

Lecture Hour(s): 4

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): HNFE 5154, HNFE 5204

Corequisite(s):

HNFE 5394:

Prof Pract Nutrition Dietetics

Final preparation for entering Registered Dietitian Nutritionist (RDN) profession. Assessment and development of entry-level professional strengths in leadership, communication, nutrition informatics, and advocacy. Job search strategies, interprofessional responsibilities, and continuing professional development planning for career and practice advancement. Performance strategies for upholding code of ethics and standards of professional practice. Application of mentoring approaches. Dissemination of practice-based research to various audiences.

Credit Hour(s): 1

Lecture Hour(s): 1

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): HNFE 5304

Corequisite(s):

HNFE 5424:

Obesity and Weight Management

Foundational knowledge addressing the prevalence, consequences, mechanisms and pathophysiology of obesity and related conditions. Guidelines for weight management, and for the prevention and management of obesity in pediatric (i.e., infancy through adolescence) and adult populations. Special populations including athletes, older adults, bariatric surgery patients, and individuals with eating disorders. Current research addressing popular diets, treatments, and trends. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

HNFE 5434:

Applications in Weight Management Practice

Applied medical nutrition therapy for adult and pediatric (i.e., infancy through adolescence) weight management practice. Assess, evaluate, and monitor weight and nutritional status of patients experiencing various diseases and medical conditions. Evidence-based strategies for working with special populations including athletes, older adults, and individuals with eating disorders. Individual and group weight

management counseling practice. Evaluation of and consumer education in popular diets and trends.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): HNFE 5126G, HNFE 5424

Corequisite(s):

HNFE 5444:

Weight Management Practicum

Practical work in weight management in clinical and community environments. Experiential pediatric (i.e., infancy through adolescence) and/or adult weight management medical nutrition therapy intervention development, implementation, evaluation, and monitoring. Standards of professionalism and ethical practice in clinical and community settings.

Credit Hour(s): 3

Lecture Hour(s): 1

Instruction Type(s): Lab, Lecture, VB, Online Lecture

Instruction Type(s): Lab, Lecture, VB, Online Lecture

Prerequisite(s): HNFE 5344, HNFE 5434

Corequisite(s):

HNFE 5454:

Nutrition and Disease Prevention Through the Life Cycle

Role of diet in health promotion and disease prevention at all stages of the life cycle. Etiology of major nutrition-related health problems. Population-level dietary nutrient requirements and dietary guidelines. Patterns in the US. Diet-related health promotion and disease prevention strategies. Pre: Graduate standing

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

HNFE 5474:

Human Exercise Testing: Physiology and Biomechanics

Mechanisms for acute and chronic physiological adaptations to exercise and muscle contraction. Interactions between physiology and biomechanics as it pertains to research outcomes. Principles of exercise and biomechanics testing for research purposes, safety considerations, factors that affect test results, and criteria to terminate tests. Research study design and methodology for specific research goals. Pre-participation screening and risk classification for exercise and biomechanics testing. Assessment of body composition, endurance,

strength, power, fatigue, and flexibility. Interpretation of exercise tests.

Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

HNFE 5604:

Principles of Public Health Nutrition

This course provides knowledge of community assessment, planning, implementation, and evaluation as related to nutrition services in health programs. It presents a conceptual background for viewing dietary as well as social, economic, and environmental factors influencing health and nutritional status of populations. I

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): HNFE 4624, HNFE 5654

Corequisite(s):

HNFE 5644G:

Advanced Health Counseling

Roles, responsibilities, legal requirements and scope of the health professional. Interviewing, counseling, education, health promotion and behavior change strategies for diverse populations. Guidance and referral, health assessment, communication skills, and problem-solving. Application of counseling techniques such as goal-setting, ethical practice, cultural competence, evidence-based practice. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

HNFE 5674:

Principles of Community Health Education

Social determinants of health (SDOH), including social class, poverty, education, race, social networks, workplace or occupation, and neighborhood environments relevant to obesity and obesity-related chronic diseases. Study design, measurement of SDOH and hypothesis testing using SDOH frameworks. Pre: Graduate Standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

HNFE 5684 (PHS 5214):

Program Development in Health Education

Theory, trends, and design of community health education programs implemented in communities, health agencies, hospitals, and industry.

Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

HNFE 5694 (PHS 5044):

Public Health Policy and Administration

Multiple dimensions of the health policy-making process including the roles of ethics and evidence. Analyzing health policies for their impact on public health and health equity. Examining the structure and function of health care models nationally and globally. Constitutional basis for public health. Applying principles of planning, organizing, directing, staffing, and budgeting to public health agencies. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

HNFE 5724:

Epidemiology

Epidemiology is the study of the distribution and determinants of the varying rates of diseases, injuries, or other health states in human and animal populations. This course consists of an introduction to epidemiological terminology, concepts and research methodology. I

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

Internship in Human Nutrition and Foods

Student participation in a planned clinical experience under supervision of a university staff member in an appropriate work center. (Maximum 12C). Consent required.

Credit Hour(s): 1 TO 12

Lecture Hour(s): 1 TO 12

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

HNFE 5764:**Externship in Human Nutrition and Foods**

Special interdisciplinary problem-solving clinics for experienced health practitioners who are engaged part-time in graduate study while continuing in positions of leadership in health organization. (Maximum 12C). Consent required.

Credit Hour(s): 1 TO 12

Lecture Hour(s): 1 TO 12

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

HNFE 5804:**Exercise Physiology**

Molecular and cellular mechanisms underlying physiological adaptations to acute and chronic exercise training. Physiological basis for current physical activity guidelines. Influences of physical activity on promotion of health and prevention and treatment of chronic diseases. Pre:

Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

HNFE 5904:**Project and Report**

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research, Online Research

Instruction Type(s): Research, Online Research

Prerequisite(s):

Corequisite(s):

HNFE 5964:**Field Work/Practicum**

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

HNFE 5974:**Independent Study**

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Independent Study, VI

Instruction Type(s): Independent Study, VI

Prerequisite(s):

Corequisite(s):

HNFE 5984:**Special Study**

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

HNFE 5994:**Research and Thesis**

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research, Online Research

Instruction Type(s): Research, Online Research

Prerequisite(s):

Corequisite(s):

HNFE 6064:**Advanced Topics in Human Nutrition, Foods and Exercise**

Critically evaluate and discuss contemporary and/or ongoing controversial issues in human nutrition, foods and exercise. May be repeated with different content for a maximum of 12 credit hours.

Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

HNFE 6234:

Theory & Practice of Community-Based Participatory Research

The theory and practice of Community-based Participatory Research (CBPR). Empirical examples from community development, agriculture and food systems, community health, and human nutrition. Principles of CBPR, practical and ethical issues in collaborating with communities, participatory action methods, and approaches to evaluation. Pre:

Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

HNFE 6984:

Special Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

HNFE 7994:

Research and Dissertation

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research, Online Research

Instruction Type(s): Research, Online Research

Prerequisite(s):

Corequisite(s):

PLANT PATHOLOGY, PHYSIOLOGY, AND WEED SCIENCE

Michael Evans, Head

Emeriti Faculty: Elizabeth Grabau; Ruth Grene; Edward Hagood; Sue Tolin;

Professors: Jeffrey Derr; Jonathan Eisenback; Chuanxue Hong; Charles Johnson; David Langston; John McDowell; David Schmale; Boris Vinatzer; James Westwood; Keith Yoder;

Associate Professors: Shawn Askew; Maria Balota; Jacob Barney; Antonius Baudoin; Eva Colla'kova'; John Jelesko; Guillaume Pilot; Steven Rideout; Xiaofeng Wang;

Assistant Professors: Michael Flessner; David Haak; David McCall; Hillary Mehl; Mizuho Nita;

Research Faculty: Elizabeth Bush; So Yon Park;

Instructors: Mary Hansen;

Graduate Contact: spesgradinfo@vt.edu

Graduate Site: <http://www.spes.vt.edu/>

As a graduate program within the School of Plant and Environmental Sciences, the core mission of the Plant Pathology, Physiology and Weed Science (PPWS) program is to optimize plant productivity and quality by limiting the impact of biotic and abiotic stresses on the profitability of crops and other plant enterprises, as well as the impact of these stresses on natural and agricultural ecosystems. The program offers a Ph.D. degree in several areas of concentration within the department: plant pathology, the study of diseases, plant pathogens and their management; plant physiology, the study of plant function, growth and development and response to environmental stresses; weed science, the study of weed biology, ecology and management; and molecular plant sciences, basic biology, biochemistry and genetics of plant and plant pathogen systems. At the master's level, PPWS students participate in the M.S. program in Life Sciences, which also allows flexibility among the different options. For the M.S., students apply to the MSLFS degree type and select PPWS as the program.

SPECIAL FACILITIES

PPWS facilities are located on-campus (Blacksburg) and at the Virginia Agricultural and Extension Centers (ARECs), including: Smyth Hall (main offices), BlacksburgPrice Hall, BlacksburgLatham Hall, BlacksburgGlade Road Complex, BlacksburgKentland Farm, BlacksburgTidewater AREC, SuffolkEastern Shore AREC, PainterSo. Piedmont AREC, BlackstoneAlson H. Smith AREC, WinchesterHampton Rds. AREC, Virginia Beach

Latham Hall

Faculty in the School of Plant and Environmental Sciences are working in Latham Hall to improve human health and nutrition, sustain the environment, and develop resilient and productive cropping systems. Extensive resources for breeding, genetics, physiology, biochemistry, molecular biology, microbiology, plant pathology, microscopy, metabolomics, genomics, tissue culture, plant transgenesis, bioinformatics, and controlled environment experiments are available for graduate research in Latham Hall.

Price Hall

DEGREES OFFERED

MS Degree

Offered In (Blacksburg)

TOEFL

Paper: (550.0)

Computer: (213.0)

iBT: (90.0)

GRE

General Test: Verbal (150.0), Quantitative (150.0), Analytical (4.0)

Masters degree: PPWS offers the M.S. degree in any of the departmental concentrations. M.S. students meet the core requirements of the M.S. in the Life Sciences program and choose electives for the plan of study in consultation with a three-person advisory committee. The M.S. requires 30 credit hours, including at least 6 research credits for the thesis option; a non-thesis option is also available. M.S. students are required to present a research seminar and a final defense seminar and participate in one teaching activity. All M.S. students meet annually with the advisory committee for an annual progress evaluation.

PhD Degree

Offered In (Blacksburg)

TOEFL

Paper: (550.0)

Computer: (213.0)

iBT: (90.0)

GRE

General Test: Verbal (150.0), Quantitative (150.0), Analytical (4.0)

Doctoral degree: PPWS offers the Ph.D. degree in any of the departmental concentrations. The Ph.D. degree requires 21 credit hours of coursework and a total of 90 credit hours for graduation. Ph.D. students develop a plan of study in consultation with a four- or five-person advisory committee in the third semester and take both written and oral preliminary examination in the fourth semester of graduate studies. Ph.D. students present two departmental seminars, a final defense seminar and participate in two graduate teaching activities. All Ph.D. students meet annually with the advisory committee for an annual progress evaluation.

GRADUATE COURSES (PPWS)

PPWS 5034:

Clinic and Field Experience

Student interns will participate in either a plant disease or a weed oriented clinic experience. Student interns will learn to diagnose and make recommendations for control of plant diseases from specimens received by the Plant Disease Clinic, or will learn to identify and make

recommendations for control of weeds received by the Weed Clinic.

Each of the two options within the course may be taken once for credit.

Credit Hour(s): 1

Lecture Hour(s):

Instruction Type(s): Lab

Instruction Type(s): Lab

Prerequisite(s): , PPWS 4754

Corequisite(s):

PPWS 5044:

Plant Bioengineering and Bioregulation

Development, deployment, and impacts of bioengineered food.

Recombinant DNA technology. Concepts, scientific and ethical issues, public concerns related to genetic engineering. Bioregulatory oversight of bioengineered products. Graduate standing

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PPWS 5054:

Plant Pathogenic Agents

Biology of plant pathogenic fungi, prokaryotes, viruses, and nematodes: morphology, taxonomy, ecology, plant-pathogen interactions, symptomatology, and selected aspects of management. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

PPWS 5064 (BIOL 5064) (ALS 5064) (BCHM 5064):

Seminar in Molecular Cell Biology and Biotechnology

Review and discussion of current problems and literature in molecular cell biology and biotechnology by students, VPI&SU faculty and outside speakers. Students give formal presentations of research results or current literature. May be taken on pass-fail basis. Students enrolled in the MCBB Ph.D. option will be required to give one formal presentation on an A-F basis.

Credit Hour(s): 1

Lecture Hour(s): 1

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PPWS 5154:

Plant Problem Diagnosis

Plant problem diagnosis in the laboratory and field, including recognition of disease, insect and abiotic (nonliving) problems, as well as the major groups of plant pathogens of a variety of regionally important horticultural and agronomic crops. General management options for pests and pathogens. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 2

Instruction Type(s): Lab, Lecture, VB, Online Lecture

Instruction Type(s): Lab, Lecture, VB, Online Lecture

Prerequisite(s):

Corequisite(s):

PPWS 5204:

Principles of Plant Disease Management

Methods of plant disease management, and theories and effectiveness of their application. Discussion based on epidemiological principles.

Methods include: cultural practices, resistance, chemical, and biological control. Laboratory 5214 supplements this course.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): PPWS 3104

Corequisite(s):

PPWS 5214:

Diseases of Crop Plants

Symptoms, pathogen morphology, etiology, epidemiology, and practical control principles for important diseases of grains, oilseeds, legumes, forages, vegetables, fruits, ornamentals, and turf. Two semesters of college biology and one course in general plant pathology or equivalent exposure required. Graduate standing required.

Credit Hour(s): 1

Lecture Hour(s): 1

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): PPWS 3104

Corequisite(s): null null

PPWS 5234:

Applied Statistics for Plant and Environmental Sciences

Experimental design, data management, practical implementation of

appropriate linear modeling statistical methods for plant, agricultural, and environmental research data. Emphasis on parametric methods, with some non-parametric analyses. Design lab/studio environment using a commercial standalone statistical program to analyze provided agricultural/environmental data sets as well as student's original research data. Design Lab/Studio.

Credit Hour(s): 3

Lecture Hour(s): 1

Instruction Type(s): Lab, Lecture, VB, Online Lecture

Instruction Type(s): Lab, Lecture, VB, Online Lecture

Prerequisite(s): STAT 5615

Corequisite(s):

PPWS 5304:

Plant Stress Physiology

Analysis of physiological responses of agricultural and native plants to environmental stresses such as extremes of temperature, availability of water and nutrients, and presence of air pollutants. Emphasis on linking stress caused changes in carbon gain, water loss, nutrient utilization, and energy balance with changes in growth. Laboratory to introduce equipment and research approaches used in greenhouse and field studies.

Credit Hour(s): 4

Lecture Hour(s): 3

Instruction Type(s): Lab, Lecture, Online Lecture

Instruction Type(s): Lab, Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PPWS 5314 (GBCB 5314):

Biological Paradigms for Bioinformatics

This course is an intensive introduction to the central paradigms of molecular cell biology for bioinformatics. Material from cell molecular biology, and genetics will be presented, and placed in a genomics context. The course prepares students in mathematical disciplines to interact in teams in the pursuit of bioinformatics research. Pre: Senior or graduate standing in mathematically-based disciplines such as computer science, statistics, mathematics or engineering.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PPWS 5344 (BCHM 5344):

Molecular Biology for the Life Sciences

A multi-disciplinary treatment of gene organization and expression in animal and plant systems. Emphasis on the applications of molecular biology to current problems in applied biology and biotechnology.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): BCHM 4116 OR BCHM 5124

Corequisite(s):

PPWS 5454:

Plant Disease Physiology and Development

Principles and concepts of infection and colonization of plants. Role of hosts and pathogens physiology and biochemistry in disease susceptibility and resistance, recognition, and disease specificity.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PPWS 5524 (HORT 5524):

Advanced Plant Physiology and Metabolism I

Plant metabolism and its regulation, cell and organ structure and function. Current understanding of photosynthesis, respiration, nitrogen fixation, mineral nutrition, water and ion transport in plant cells and tissues, ecophysiology and responses of plants to the environment. Pre: undergraduate major in biology or related discipline.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PPWS 5534:

Advanced Plant Physiology and Metabolism II

Presentation of the current understanding of metabolic and functional relationships among primary and secondary metabolites and storage products and their impact on the whole plant. Biosynthesis of phytohormones. Mechanisms controlling responses to phytohormones including: impact on carbon/nitrogen partitioning, senescence, development of higher plant structures such as vascular tissue and flowers. Pre: undergraduate major in Biology or related discipline.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PPWS 5604G:

Adv Biological Invasions

Causes, consequences, and epidemiology of invasive plants animals, and microbes. Conceptual, mechanistic, societal, and political components of invasive species from Darwin to modern day; invasion process from introduction to ecological or economic impact. Taxonomy, management, and risk assessment, within a policy context. Pre:

Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 2

Instruction Type(s): Lab, Lecture, Online Lecture

Instruction Type(s): Lab, Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PPWS 5624:

Animal and Plant Biosafety and Biosecurity

Principles, tools, and techniques of disease detection, early warning, and containment of animal and plant pathogens. Regulatory agencies and guidelines used to ensure the biosafety and biosecurity of the US food supply from accidental introductions and potential bioterrorism.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): PPWS 5044

Corequisite(s):

PPWS 5704:

Weed Science and Management

Biological and ecological principles that influence persistence and spread of weeds. Weed genetics and the dynamics of plant species and communities, with emphasis on invasive species. Characteristics of herbicide action and metabolism that influence selectivity, resistance, and fate. Genetic engineering of herbicide resistant crops. Analysis of weed control programs for specific crops Pre: Two semesters of college biology and chemistry or two years experience in agricultural production, industry, or policy. Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

543 Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PPWS 5714:

Molecular Biology for Applied Plant Sciences

Fundamental principles of molecular biology and genomics in applied plant production disciplines. Applications of molecular biology to research through problem-based, hands-on methods in plant pathology and weed control. Pre: Graduate Standing.

Credit Hour(s): 3

Lecture Hour(s): 2

Instruction Type(s): Lab, Lecture, VB, Online Lecture

Instruction Type(s): Lab, Lecture, VB, Online Lecture

Prerequisite(s):

Corequisite(s):

PPWS 5894:

Final Exam (Non-Thesis)

For students pursuing a non-thesis Masters degree, who have completed all other course work.

Credit Hour(s): 3

Lecture Hour(s): 0

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PPWS 5904:

Project and Report

For students pursuing a non-thesis Masters degree. Projects may involve guided research or an internship.

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research, Online Research

Instruction Type(s): Research, Online Research

Prerequisite(s):

Corequisite(s):

PPWS 5974:

Independent Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Independent Study

Instruction Type(s): Independent Study

Prerequisite(s):

Corequisite(s):

PPWS 5984:

Special Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PPWS 5994:

Research and Thesis

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research

Instruction Type(s): Research

Prerequisite(s):

Corequisite(s):

PPWS 6004:

Advanced Topics in Plant Pathology, Physiology, and Weed Science

In depth presentations and discussions on selected advanced topics in plant pathology, physiology, and weed science. May be repeated.

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PPWS 6984:

Special Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PPWS 7994:

Research and Dissertation

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research

Instruction Type(s): Research

Prerequisite(s):

Corequisite(s):

GOVERNMENT AND INTERNATIONAL AFFAIRS

Ariel Ahram, Chair

Professors: Timothy Luke; Joel Peters; Joyce Rothschild; Gerard Toal;

Associate Professors: Ariel Ahram; Giselle Datz;

Affiliated Faculty: Matthew Dull; Ilja Luciak; Randall Murch; David Orden;

Georgeta Pourchot; Ioannis Stivachtis; Edward Weisband; Kris Wernstedt;

General Contact: mlechuga@vt.edu

Graduate Contact: ahram@vt.edu

Graduate Site: <https://spia.vt.edu/programs/gia.html>

Student Handbook: <https://www.gia.vt.edu/degrees-certificates/masters/>

The analysis of government and international affairs during the 21st century clearly constitutes a complex and interdisciplinary set of challenges. To be effective, such study requires knowledge from all of the social sciences and humanities. This program in the School of Public and International Affairs (SPIA) draws insights from these areas of learning into the multidimensional study of governance processes in all levels of society and international affairs. The faculty and students in the Government and International Affairs (GIA) program work jointly to cultivate their experience, knowledge, and skill with regard to the governance practices, political institutions, social dynamics, cultural values, workplace conditions, spatial formations, historical trends, and ethical conflicts that intersect in the workings of government, business, and not-for-profit organizations. Therefore, methodological pluralism is the foundation of GIA's scholarly pursuits. This program approaches the challenges of governance and international affairs comparatively, empirically, and historically at each level of activity and analysis to see how the processes of globalization are being shaped and what their implications may be. We also consider carefully the requirements for more democratic governance of the economy and society. The faculty's key educational objectives are to conduct research, perform service, and train graduate students at both the master and doctoral levels of study in a manner that can engage the GIA program as well as the larger School of Public and International Affairs at Virginia Tech in the public life of our nation and the world. Through this work, the GIA program contributes to the development of new knowledge, enhances global well-being, and prepares all its graduates with the latest skills for conducting their research, service, and teaching. The Government and International Affairs Program offers two graduate degrees: a Master's in Public and International Affairs (MPIA), and a Ph.D. in the Governance & Globalization (G&G) Stream of the Planning, Governance & Globalization Ph.D. program (PG&G), which is a wide program in which most of the departments, programs, and schools in the College of Architecture and Urban Studies now participate. The goal of these two

GIA graduate programs is to prepare SPIA graduates for a life-long, rich, and full engagement in public activity, continuing professional development, and effective service as academics, government officials, journalists or technical experts in the vitally important fields of government and international affairs. The overall unifying focus of the School of Public and International Affairs is directed at issues in politics, policy, planning, and practice. GIA students will work closely with faculty and students in the school's two sister programs Public Administration and Public Policy as well as Urban Affairs and Planning and those departments in the other collegiate units at Virginia Tech that can assist them with their education.

SPECIAL FACILITIES

Contact Myriam Lechuga at National Capital Region Center for more information. mlechuga@vt.edu

Facilities

For information on facilities, please contact Myriam Lechuga or Julie Hudson for further details.

DEGREES OFFERED

MPIA Degree

Offered In (National Capital Region)

TOEFL

Paper: (620.0), Essay Writing Score (4.5)

Computer: (260.0), Essay Writing (4.5)

iBT: (105.0), Essay Writing (26.0)

GRE [Optional]

General: Verbal, Quantitative, Analytical

MAXIMUM AND MINIMUM REQUIREMENTS FOR MASTERS

DEGREE Project and Report (Choice of Major Paper or Practicum)*

Option5000-6000 level courses 33 credit hours5904 Project & Report 3 credit hours or5964 Field Work/Practicum 3 credit

hoursThesis Option5000-6000 level courses 30 credit

hours5994 Research & Thesis 6 credit hoursTotal Hours for all

Capstone Options: 36 credit hours[Further information found in Student

Handbook] All MPIA students have Major Paper or Practicum as options. Full-time students have Thesis option.

GRADUATE COURSES (GIA)

GIA 5004 (UAP 5004):

Power and Policy in the U.S.

Social science theory and research on the distribution of power in the US, especially as it shapes important national policy outcomes.

Institutional and class bases of power will be examined, including membership on corporate boards and in policy-shaping think tanks.

Implications for democracy in society will be drawn. Graduate standing.

Credit Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

GIA 5034 (UAP 5034):

Democratic Governance in the Economy

Interplay between democratic politics upon economic relations, with special focus on the intellectual foundations of capitalist development and consequences of financial disruption to economic policy making. Evolution of state-market interactions and of global governance institutions. Case studies of financial crises and their political implications. Pre: Graduate Standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

GIA 5115 (PSCI 5115):

Research Methods I

The purposes, problems, and strategies of political science research, emphasizing concept and hypothesis formulation, operationalization, research design, data collection techniques, data processing, and multivariate data analysis.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

GIA 5116 (PSCI 5116):

Research Methods I

The purposes, problems, and strategies of political science research, emphasizing concept and hypothesis formulation, operationalization, research design, data collection techniques, data processing, and multivariate data analysis.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

GIA 5164:

Collaborative Governance and Civil Society

Theoretical foundations of collaborative policy and governance approaches are examined. Strategies and methods for forming and sustaining collaborative coalitions are discussed. Case studies are used to illustrate the effectiveness of collaborative approaches in different policy domains.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

GIA 5214 (PSCI 5214):

Contemporary Political Theory

Selected topics in contemporary political theory, including different models of social science inquiry and the use of basic concepts like power, ideology, rationality, and the state in the study of politics.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

GIA 5224:

Perspectives Pol Theo

Analysis of selected perspectives on politics including rational choice theory, critical theory, neo-marxism, neo-conservatism, post-industrialism, and post-structuralism.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

GIA 5254 (PSCI 5514):

Global Conflicts

Examines theoretical issues in the study of global conflicts. Reviews theories of nationalism, states and territory as factors. Examines dynamics of contemporary conflicts from different regions of globe as case studies illustrating theoretical issues. Reviews role of leaders in conflict processes. Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

546 Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

GIA 5274:

Comparative Social Movements

This course will investigate the forms of public protest that occur all over the world, with special attention to activism in poor nations and to the recent emergence of transnational movements. Also examines why and when governments repress social movements. Explores movements that are grounded in collective identities based in class, race/ethnicity, gender, religion, and culture. Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

GIA 5284 (PSCI 5284):

Transnational Migration

Overview of the dynamics, policies, governance, and citizenship regimes associated with the phenomenon of transnational migration. The course will emphasize local, national, and supranational examples and comparisons to explore these themes. Graduate standing

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

GIA 5314:

Middle East Geopolitics

Key issues in international relations in the Middle East, including impact of political geography, emergence of regional systems, relationship between identity and citizenship, domestic and transnational political contestation, and U.S. regional policy. Application of theories of social change to examine linkage between citizenship, religion, and political authority. Focus on Iraq, Iran, Syria, Lebanon, and Persian Gulf region.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

GIA 5354 (PSCI 5354):

Public Policy Analysis

Approaches to policy analysis and program evaluation including the techniques appropriate to various stages of the policy process.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

GIA 5364 (PSCI 5364) (STS 5364):

Public Ecology

Examines policy developments and practices that move beyond the conceptual divisions and policy operations begun during the 1970s, which largely divided the more natural science- based environmental sciences from social science-based environmental based studies. Mixes the insights of life science, physical science, social science, applied humanities, and public policy into a cohesive conceptual and operational approach to environmental protection in the 21st century. Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

GIA 5374:

Electronic Governance

Examines applications of information technology in government from the point of view of governments and citizens. Survey of the relationship between e-government and e-democracy and of government management techniques. Explores problematic issues related to e-government, such as privacy, the digital divide, and information security.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): PSCI 5214, PSCI 5554 OR UAP 5564

Corequisite(s):

GIA 5404 (GEOG 5424):

Topics in Political Geography

Territorial basis of political systems, political processes, and political behavior from local to global scales; evolution of contemporary political

earth.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

GIA 5414 (PSCI 5414):

Industrial Democracies

Political pattern and processes of development in selected democracies in Europe, North America, and Asia emphasizing the political problems of contemporary industrial societies and their likely evolution in a post-industrial era.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

GIA 5424 (PSCI 5424):

Comm & Post-Comm Sys

Political processes and developmental trends in communist and post-communist systems in Russia and other CIS states, Eastern Europe, the Peoples Republic of China, and the Third World. Current economic, political, and social issues and their likely development.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

GIA 5434 (PSCI 5434):

Politics of Developing Areas

Political structures, economic growth, and cultural frameworks of developing nations in Asia, Africa, and Latin America emphasizing the political and economic challenges of industrial development in a global economy.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

GIA 5444 (PSCI 5444):

International Politics

Theories of international organizations and relations among nations focusing on research in foreign policy formulation and implementation, international integration, conflict resolution, and global political economy.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

GIA 5454:

Adv Info Tech Policy

In-depth study and critical evaluation of selected complex issues related to information technology, society, governance, and public policy.

Focused attention is given to theoretical and methodological foundations of the area of inquiry and to specific domains of policymaking and implementation. Topics will be selected from IT-related issues in such areas of concern as: cities, local communities, nonprofit organizations, governments, and global networks. May be repeated on a different topic. Must meet prerequisite or have permission of instructor.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

GIA 5464 (UAP 5464):

Qualitative Research Methods in Global Studies

Examines the philosophies and procedures guiding various qualitative methods used in the social science fields, such as global studies, planning and policy. Exploration of alternative understandings of normal science and consideration of the merits of adopting qualitative research approaches to disciplined analysis, including ethical issues in research.

Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

GIA 5474 (PSCI 5474):

Global Governance

international community to address systemic global governance problems: genocide, failed states, transnational corruption, displaced persons, AIDS, poverty. Role of United States in world community examined. Power of international organizations versus states. Capacity problems of both. Future of United Nations and global governance considered. Graduate Standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

GIA 5484 (HIST 5484) (PSCI 5484):

Contemporary American Foreign Policy

Covers U.S. foreign policy during the Cold War, the stalemate with the Soviet Union, armament and arms control, containment and deterrence, detente and Reaganism, and the end of the Cold War. Briefly covers events from 1989 to the present. Designed for students with an interest in foreign policy and global affairs. Prereqs or instructors permission.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): PSCI 5214, PSCI 5444

Corequisite(s):

GIA 5504 (PSCI 5504) (UAP 5504):

Discourse Analysis

Examines the key theoretical sources and major practical applications of discourse analysis as a contemporary social science methodology.

Origins, major variants, and critical uses of discourse analysis in cultural studies, semiotic methods, policy analysis, and organizational communication techniques also are considered. Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

GIA 5514 (PSCI 5514):

Global Security

Security examined as an essentially contested concept. Traditional national security and emergent global security discourses and agendas explained. Security institutions and organizations analyzed. Questions of power, identity and representation examined as factors delimiting

security conceptions, practices and agendas. Graduate Standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

GIA 5524 (UAP 5524):

Internat Development

Social and cultural factors in the development of societies, including the role of women in development. Contemporary developing countries, and historical material from developed countries; policy issues facing governments of developing countries and those interested in assisting their development.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

GIA 5534:

Regionalism and Political Development

Provides a systematic review of regional organizations, the theories and factors that explain their recent emergence and an analytical framework for studying regional policy objectives such as peace and security, economic growth, environmental protection and the pursuit of human rights. Regional variations between Europe, Latin America, Asia, Africa and the Middle East are examined.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): GIA 5444 OR PSCI 5444

Corequisite(s):

GIA 5554:

Cult Pol Soc Network

Historical origins, institutional foundations, and theoretical interpretations of cultural, political, and social interaction through computer mediated communication are examined. Particular attention is given to new types of discourse, sources of power, and structures of society at all geographical levels in global computer and communications networks.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

GIA 5564:

Women and Globalization

Feminist theoretical paradigms that analyze impacts of globalization on women and girls. Impacts of globalization on households and families.

Relationship between globalizing processes and gender inequalities.

Addresses feminist controversies and womens transnational resistance.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

GIA 5584 (UAP 5584) (PSCI 5584):

Environmental Politics and Policy

Course provides a broad introduction to the key ideas, actors and institutions related to environmental politics and policy in the United States, with some coverage of global issues. It is intended to provide students with basic interdisciplinary knowledge and an intellectual framework for understanding and thinking critically about environmental politics and policy.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

GIA 5614 (PSCI 5614) (HIST 5544):

Understanding The Israeli Palestinian Conflict

Dynamics of the Israeli-Palestinian conflict. Critical issues that underlie the conflict and divide Israel and the Palestinians. Diplomatic efforts aimed at resolving the conflict. Pre: Graduate Standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

GIA 5624:

Conflict Resolution and Peace Building

Comprehensive guide to contemporary conflict resolution. Strategies and

approaches for mitigating and resolving conflict. Process of conflict transformation and reconciliation. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

GIA 5634:

Global Social Policy

History of national and global welfare regimes since WWII. Theories of comparative welfare regimes and the emergence of global welfare regimes. Application of theories of social rights and human rights to contemporary issues in social policy at a global level and intersections with international development policy. Pre: Graduate Standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

GIA 5664:

Energy and Environmental Security

Effect of energy and natural resources on conflict, security, and risk. Theories of scarcity and human ecology pertaining to causes of wars and insecurity. Identification drivers of risk, resilience, and sustainability through case studies and statistical data related to different natural resources. Pre: Graduate Standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

GIA 5904:

Project and Report

The major paper is one option (together with the Practicum and Thesis) which GIA candidates may elect to complete their degree requirements. It provides the candidate with an opportunity to demonstrate: (1) a required degree of comprehension of the concepts, principles and theories relevant to their fields and (2) the ability to apply this understanding in a professional manner to a specific policy, planning or methodological issue by means of a sustained analytic argument. The exact character of the concerns to be examined in a major paper will be

approved by a students committee and may take the form of case studies, literature reviews, or sustained examination of policy or planning processes or outcomes.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Research, Online Research

Instruction Type(s): Research, Online Research

Prerequisite(s): null null

Corequisite(s):

GIA 5914:

Peace Corps Service Credits

Critical evaluation and field-based study of selected complex issues related to society in international context; study of cultural and language diversity; approaches to ethnoinclusiveness in urban and rural environments; focus on practical local and regional planning for the benefit of local communities in consort with nonprofit organizations, governments and global networks. Prerequisite: Graduate Standing and enrollment in Masters International Program and Peace Corps.

Credit Hour(s): 6

Lecture Hour(s): 6

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

GIA 5964:

Field Work/Practicum

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

GIA 5974:

Independent Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Independent Study

Instruction Type(s): Independent Study

Prerequisite(s):

Corequisite(s):

GIA 5984:

Special Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

GIA 5994:

Research and Thesis

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research

Instruction Type(s): Research

Prerequisite(s):

Corequisite(s):

GIA 6114 (PSCI 6114):

Critical Geopolitics

Critical analysis of geopolitics as spatial discourse about world politics. Examines major concepts in critical geopolitics. Critically reads colonial, fascist, Cold War and post-Cold War geopolitical discourses. Discusses geopolitical knowledge in popular culture. Reviews latest research in the field of critical geopolitics. Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): PSCI 5444

Corequisite(s):

GIA 6124:

Topics in Security Studies

Surveys the interface of globalization and security and the changing paradigm of security within global society. Reviews the impact of globalization on traditional understandings of state security, and provides an advanced understanding of the emerging challenges and threats to human and state security. May be repeated with a different topic content for a maximum of 12 credits.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): GIA 5444 OR PSCI 5444 OR GIA 5514 OR PSCI 5514

551 Corequisite(s):

Prerequisite(s): UAP 5264 OR GIA 5264

Corequisite(s):

GIA 6134:

Topics in Conflict Analysis

Provides a comprehensive guide to the understanding of contemporary global conflicts and conflict resolution. Reviews the field of conflict analysis, demonstrates the various approaches to conflict resolution and explores the dynamics of conflict settlement. May be repeated with a different topic content for a maximum of 12 credits.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): GIA 5254 OR UAP 5254 OR PSCI 5254

Corequisite(s):

GIA 6144:

Topics in Global Governance

Provides a comprehensive guide to understanding of contemporary power pressures and responses to global economic and financial change along with its political and social repercussions. Reviews the fields of international political economy, demonstrates the various approaches to adherence and resistance to globalization, and explores the dynamics of the relationship between states and markets. May be repeated with a different topic content for a maximum of 12 credits.

Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): GIA 5034 OR UAP 5034 OR PSCI 5034

Corequisite(s):

GIA 6204:

Theories in Globalization

Examination of past and present eras of globalization through various theoretical perspectives. Addresses colonialism and emergence of western models for development of poor countries. Controversies about impacts of current globalization on the nation-state, cultures, ecosystems, and racial/ethnic/gender inequalities. Explores present trends, such as globalization of agriculture and food systems, industrial production, migration, human rights, and anti-globalization resistance.

Prerequisite may be substituted for any equivalent 5000 level international course.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

GIA 6214 (PSCI 6214):

Democracy Beyond the Ballot

Forms of ultra or enhanced democracy outside of state institutions, particularly those developing in third sector organizations, theories of democracy and research on functioning deliberative democracies at the grassroots level, in societal or international institutions. Graduate standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): GIA 5034 OR UAP 5034 OR PAPA 5034 OR GIA 5164 OR UAP 5164

Corequisite(s):

GIA 6224:

Competing Conceptions of the Third Sector

Competing theories and conceptions of the third sector in relation to the for-profit firm and the state with international perspectives on voluntary grassroots action challenges and societal transformation. Integration of theoretical and research literatures in the field. Graduate Standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): GIA 5034 OR UAP 5034 OR PAPA 5034 OR GIA 5164 OR UAP 5164

Corequisite(s):

GIA 6984:

Special Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

GIA 7994:

Research and Dissertation

NONE

552 Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research

Instruction Type(s): Research

Prerequisite(s):

Corequisite(s):

FOREST PRODUCTS

Audrey Zink-Sharp, Associate Head

Ching-Hsun Huang, Head

Professors: Brian Bond; Urs Buehlmann; Robert Bush; Kevin Edgar; Charles

Frazier; A Hammett; Ching-Hsun Huang; David Kline; Joseph Loferski; Robert

Smith; Paul Winistorfer; Audrey Zink-Sharp;

Associate Professors: Daniel Hindman; Laszlo Horvath; Henry Quesada; Maren

Roman;

Assistant Professors: Young Kim; Jennifer Russell;

General Contact: garmandd@vt.edu

The Department of Sustainable Biomaterials is one of the leading academic programs in North America. We support a large graduate education program where students are engaged in research. Due to the nature of sustainable biomaterials, we have considerable interaction in our graduate education and research endeavors with other departments, colleges, centers and institutes on the Virginia Tech campus. Our faculty expertise is diverse and experienced in support of our graduate education mission. We provide educational and research opportunities in the areas of sustainable biomaterials, spanning the range from nanotechnology and the basic science of wood and other renewable materials, through processing, manufacturing, marketing, management, and competitiveness aspects of the various biomaterials industries. Some of our research is done in concert with our faculty-directed research centers and is supported by these Centers and their external cooperators. General areas of degree specialization within our graduate program include: Forest Products Marketing, Non-Timber Forest Products, Packaging Science, Pallet and Container Design, Wood Engineering, Wood Performance in Structures, Composites, Adhesion, Wood Formation, Cell Wall Architecture, Bio-Materials, Lumber Drying and Processing, Lean Manufacturing, Wood Industry Management, Packaging for Modern Supply Chains, Packaging and Unit Load Design

SPECIAL FACILITIES

Excellent laboratory and classroom resources are available for education, research, and outreach in Blacksburg, Virginia and other locations across Virginia. Faculty, staff, and student researchers have access to research laboratories in several locations, principally Cheatham Hall on the main campus in Blacksburg and the Brooks Forest Products Center located approximately 1.5 miles from the main campus in the Virginia Tech Corporate Research Center. Cheatham Hall has space for research, education, and application short courses plus natural resource research laboratories and college-wide computing facilities. Our laboratories have capabilities for liquid and gas chromatographic separation of wood components, thermal analysis of

cellulose materials, molecular weight determination, nuclear magnetic resonance, dynamic mechanical analysis, FT-IR and UV-VIS spectroscopy, contact angle analysis, light and electron microscopic study of structure and properties, and wide-angle X-ray diffraction for crystallinity and microfibril angle analysis. The Brooks Center has classrooms, offices, and laboratories for the manufacture of pressed panels, several engineering testing machines, wood and metal working shops, pallet and container research facilities, packaging research equipment, and other wood and fiber-based composite testing instrumentation.

DEGREES OFFERED

PhD Degree

Offered In (Blacksburg)

TOEFL

Paper: (550.0)

Computer: (213.0)

iBT: (80.0)

GRE

General Test: Verbal, Quantitative, Analytical

All program degree requirements and supplemental information about graduate education in our department is summarized in our annually updated Graduate Student Policy and Procedures manual, available online on our department website. This manual describes all required coursework, graduation and other requirements, and activities associated with graduate education in our department. The department offers three degrees: Master of Forestry (M.F.), Master of Science (M.S.) in Forestry and Forest Products, and Doctor of Philosophy (Ph.D.) in Forestry and Forest Products. The M.S. and Ph.D. degrees require students to prepare a thesis or dissertation, and considerable time spent working for these degrees is devoted to research. The M.F. degree is a professional, non-research, non-thesis degree for those who wish to expand their post-baccalaureate education. Master of Forestry The M.F. is a non-thesis degree intended to serve the needs of those who have a prior sustainable biomaterials degree and who wish to enhance their knowledge and skills, or those who have no previous degree in sustainable biomaterials. In addition to formal course work at the graduate and senior undergraduate levels that is commensurate with the objectives of the student's degree program, a substantive paper worth three to six hours of academic credit is required. A minimum credit hours in formal course work, inclusive of hours credited towards the degree paper, must be passed with a minimum GPA of 3.0 for courses in the program of study. The M.F. student must pass a comprehensive oral examination covering her/his course work and the degree paper. All Graduate School requirements apply to the nature and timing of the candidate's final examination. Master of Science The M.S. is a research-based degree. Students work closely with a faculty advisor and graduate committee on original research. Advanced coursework is expected in the areas of expertise required to complete the research project. Students complete a thesis and are expected to publish their research results in peer-reviewed scientific journals at the completion of their degree. Graduates are prepared to continue their professional careers or undertake further study through a Ph.D. program. All Graduate School requirements apply regarding the number of credit hours and level of courses required on a student's Plan of Study. M.S. students must complete a research working plan by the end of the second academic semester. Guidelines for the preparation and submission of the working

plan are listed in the College of Natural Resources & Environment (CNRE) graduate program procedures. M.S. students must pass a final exam. The examination will be a defense of the thesis and an assessment of the student's understanding of appropriate related subjects. Doctor of Philosophy Each Ph.D. student must complete a minimum of 90 credit hours of graduate study and a dissertation. The Plan of Study must meet minimum Graduate School requirements; in addition, a student's advisory committee may add specific requirements needed for an individual student's academic development. Ph.D. students must complete a research working plan by the end of the third academic semester. Guidelines for the preparation and submission of the working plan are listed in the College of Natural Resources & Environment (CNRE) graduate program procedures. A preliminary exam, oral and/or written, is conducted by the student's advisory committee. It is comprehensive in nature and intended to test a student's ability to integrate, synthesize, and apply concepts, facts, and techniques in solving new and complex problems associated with sustainable biomaterials. The student may be tested on any aspect of sustainable biomaterials science, the philosophy of science, and research methodology. The final exam is primarily a defense of the dissertation, but other areas of science may be included. Ph.D. students are expected to publish their research results in peer-reviewed scientific journals at the completion of their degree.

MS Degree

Offered In (Blacksburg)

TOEFL

Paper: (550.0)

Computer: (213.0)

iBT: (80.0)

GRE

General Test: Verbal, Quantitative, Analytical

All program degree requirements and supplemental information about graduate education in our department is summarized in our annually updated Graduate Student Policy and Procedures manual, available online on our department website. This manual describes all required coursework, requirements and activities associated with graduate education in our department. The department offers three degrees: Master of Forestry (M.F.), Master of Science (M.S.) in Forestry and Forest Products, and Doctor of Philosophy (Ph.D.) in Forestry and Forest Products. The M.S. and Ph.D. degrees require students to prepare a thesis or dissertation, and considerable time spent working for these degrees is devoted to research. The M.F. degree is a professional, non-research degree for those who wish to expand their post-baccalaureate education. Master of Forestry The M.F. is a non-thesis degree intended to serve the needs of those who have a prior sustainable biomaterials degree and who wish to enhance their knowledge and skills, or those who have no previous degree in sustainable biomaterials. In addition to formal course work at the graduate and senior undergraduate levels that is commensurate with the objectives of the student's degree program, a substantive paper worth three to six hours of academic credit is required. A minimum of 33 credit hours in formal course work, inclusive of hours credited towards the degree paper, must be passed with a minimum GPA of 3.0 for courses in the program of study. The M.F. student must pass a comprehensive oral examination covering his/her course work and the degree paper. All Graduate School requirements apply to the nature and timing of the candidate's final examination. Master of Science The M.S. is a research-based degree. Students work closely with a faculty advisor and graduate

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MF Degree

Offered In (Blacksburg)

TOEFL

Paper: (550.0)

Computer: (213.0)

iBT: (80.0)

GRE

General Test: Verbal, Quantitative, Analytical

All program degree requirements and supplemental information about graduate education in our department is summarized in our annually updated Graduate Student Policy and Procedures manual, available online on our department website. This manual describes all required coursework, requirements and activities associated with graduate education in our department. The department offers three degrees: Master of Forestry (M.F.), Master of Science (M.S.) in Forestry and Forest Products, and Doctor of Philosophy (Ph.D.) in Forestry and Forest Products. The M.S. and Ph.D. degrees require students to prepare a thesis or dissertation, and considerable time spent working for these degrees is devoted to research. The M.F. degree is a professional, non-research degree for those who wish to expand their post-baccalaureate education. Master of Forestry The M.F. is a non-thesis degree intended to serve the needs of those who have a prior sustainable biomaterials degree and who wish to enhance their knowledge and skills, or those who have no previous degree in sustainable biomaterials. In addition to formal course work at the

graduate and senior undergraduate levels that is commensurate with the objectives of the student's degree program, a substantive paper worth three to six hours of academic credit is required. A minimum of 33 credit hours in formal course work, inclusive of hours credited towards the degree paper, must be passed with a minimum GPA of 3.0 for courses in the program of study. The M.F. student must pass a comprehensive oral examination covering his/her course work and the degree paper. All Graduate School requirements apply to the nature and timing of the candidate's final examination. Master of Science The M.S. is a research-based degree. Students work closely with a faculty advisor and graduate committee on original research. Advanced coursework is expected in the areas of expertise required to complete the research project. Students complete a thesis and are expected to publish their research results in peer-reviewed scientific journals at the completion of their degree. Graduates are prepared to continue their professional careers or undertake further study through a Ph.D. program. All Graduate School requirements apply regarding the number of credit hours and level of courses required on a student's Plan of Study. M.S. students must complete a research working plan by the end of the second academic semester. Guidelines for the preparation and submission of the working plan are listed in the College of Natural Resources & Environment (CNRE) graduate program procedures. M.S. students must pass a final exam. The examination will be a defense of the thesis and an assessment of the student's understanding of appropriate related subjects. Doctor of Philosophy Each Ph.D. student must complete a minimum of 90 credit hours of graduate study and a dissertation. The Plan of Study must meet minimum Graduate School requirements; in addition, a student's advisory committee may add specific requirements needed for an individual student's academic development. Ph.D. students must complete a research working plan by the end of the third academic semester. Guidelines for the preparation and submission of the working plan are listed in the College of Natural Resources & Environment (CNRE) graduate program procedures. A preliminary exam, oral and/or written, is conducted by the student's advisory committee. It is comprehensive in nature and intended to test a student's ability to integrate, synthesize, and apply concepts, facts, and techniques in solving new and complex problems associated with sustainable biomaterials. The student may be tested on any aspect of sustainable biomaterials science, the philosophy of science, and research methodology. The final exam is primarily a defense of the dissertation, but other areas of science may be included. Ph.D. students are expected to publish their research results in peer-reviewed scientific journals at the completion of their degree.

GRADUATE COURSES (SBIO)

SBIO 5004:

Forest Products Graduate Seminar

Gives graduate students experience in presenting results or reviews of forest products and wood science topics. The course also provides opportunities for students to learn about recent developments in forest products from invited speakers.

Credit Hour(s): 1

Lecture Hour(s): 1

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

SBIO 5114:

Professional Skills for Sustainable Biomaterials Graduate Students

Skills for success in graduate programs and professional employment.

Literature reviews, ethics, professional presentations, laboratory safety, technical writing, reviewing scholarly works, publishing research results, research misconduct. Pass/Fail Only. Pre: Graduate Standing.

Credit Hour(s): 2

Lecture Hour(s): 2

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

SBIO 5124:

Wood Material Science

Advanced and comprehensive treatment of wood material science including wood anatomy and formation, mechanical and physical properties, and wood polymer science.

Credit Hour(s): 4

Lecture Hour(s): 3

Instruction Type(s): Lab, Lecture, Online Lecture

Instruction Type(s): Lab, Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

SBIO 5224:

Quantitative Wood Anatomy

Formation, composition, and arrangement of the anatomical elements of tree stem wood. Preparation methods and examination of wood and wood fiber with light and scanning electron microscopy and select methods for quantitative characterization of wood anatomical structure.

Pre-requisite: Graduate Standing required

Credit Hour(s): 2

Lecture Hour(s): 1

Instruction Type(s): Lab, Lecture, Online Lecture

Instruction Type(s): Lab, Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

SBIO 5324:

Timber Engineering

Rationale behind current design procedures for wood structures and components. Advanced topics such as reliability-based design, fracture mechanics, cumulative damage theory, and the effects of a changing

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): null null

Corequisite(s):

SBIO 5424G:

Adv Polysaccharide Chemistry

Structure, properties, and applications of natural polysaccharides.

Natural sources and methods of isolation. Synthetic chemistry and important polysaccharide derivatives Relation of structure and properties to performance in critical applications including pharmaceuticals, coatings, plastics, rheology control, and films. Conversion by chemical and biochemical methods of polysaccharide biomass to fuels and materials. Pre: Graduate Standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

SBIO 5614:

Forest Products Marketing and Management Strategies

Examination of forest products markets, industry structure, distribution channels, and strategic management trends. Case studies demonstrate the impact of these factors on decision-making in the forest products industry.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): SBIO 4614 OR FREC 3424

Corequisite(s):

SBIO 5894:

Final Examination

NONE

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

SBIO 5954:

Study Abroad

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

SBIO 5974:

Independent Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Independent Study

Instruction Type(s): Independent Study

Prerequisite(s):

Corequisite(s):

SBIO 5984:

Special Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

SBIO 5994:

Research and Thesis

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research

Instruction Type(s): Research

Prerequisite(s):

Corequisite(s):

SBIO 7994:

Research and Dissertation

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research

Instruction Type(s): Research

Corequisite(s):

BIO-INSPIRED BUILDINGS

Professors: Virginia Buechner-Maxwell; Ignacio Moore;

Associate Professors: Bryan Brown; Michael Garvin; Rolf Mueller; Annie Pearce;
Georg Reichard; Walid Saad;

Assistant Professors: Jonathan Boreyko; Steven Hankey; Farrokh Jazizadeh
Karimi; Frederick Paige; Earl Shealy;

General Contact: biobuild@vt.edu

Graduate Site: <http://biobuild.mlsoc.vt.edu>

This doctoral program answers the pressing societal need for professionals with the interdisciplinary expertise necessary to redefine how we develop buildings, infrastructure and communities. The emerging fields of bio-inspiration and bio-integration provide paths towards this objective. A bio-inspired built environment capitalizes on the regulative, adaptive, and integrative characteristics of biological systems and incorporates these features into the constructed world. Likewise, a bio-integrated built environment situates constructed facilities amidst natural systems to achieve symbiosis. In doing so, buildings and infrastructure will more optimally respond to changing conditions and expectations – which will make the interdependent built environment more sustainable, parsimonious, and resilient, as well as ecologically integrated. Graduates will have an immediate impact in university and industrial settings, and they will change the relationship between the built environment and our planet. We do this by bringing together faculty from departments in CAUS, COE, COS and CVM to deliver a program that explores the built environment and biological systems synergistically to discover innovative connections between these two fields. BioBuild Fellows can receive from 12 to 36 months of financial support from the program while working toward a degree in one of the departments listed below. To receive full consideration for financial support in the following academic year, applications should be submitted by January 15 for fall entry or September 15 for spring entry. Participating Colleges, Departments and Faculty: College of Architecture & Urban Studies (CAUS) Building Construction - Annie Pearce, Georg Reichard Urban Affairs & Planning - Steve Hankey College of Engineering (COE) Biomedical Engineering & Mechanics - Jonathan Boreyko Civil and Environmental Engineering - Michael Garvin, Farrokh Jazizadeh, Freddy Paige, Tripp Shealy Electrical and Computer Engineering - Walid Saad Mechanical Engineering - Rolf Mueller College of Science (COS) Biological Sciences - Bryan Brown, Ignacio Moore College of Veterinary Medicine (CVM) Large Animal Clinical Sciences – Virginia Buechner-Maxwell For more information please visit our web-site at biobuild.mlsoc.vt.edu or contact Dr. Annie Pearce at apearce@vt.edu or send a general request for information to biobuild@vt.edu.

SPECIAL FACILITIES

Our program involves multiple colleges and departments so facilities from across campus are utilized to support the program. The program is headquartered in Bishop-Favrao Hall, which was opened in 2007 and includes state-of-the-art classrooms, meetings rooms and faculty/student offices. It is also the home of the Myers-Lawson School of Construction

and the Department of Building Construction. Additional facilities supporting the program include Derring Hall, Goodwin Hall, Norris Hall and Patton Hall where faculty from the Department of Biological Sciences, the the Department of Mechanical Engineering, the Department of Biomedical Engineering & Mechanics and the Via Department of Civil & Environmental Engineering have laboratory and office space respectively.

Facilities

This is an interdisciplinary program and shares facilities among departments across campus. Facilities are located in Bishop-Favrao Hall, Derring Hall, Goodwin Hall and Patton Hall.

DEGREES OFFERED

IGEP Degree

Offered In (Blacksburg)

TOEFL

Paper: (550.0)

iBT: (88.0)

Students in the Bio-inspired Buildings (BioBuild) program earn a degree from one of the participating degree-granting programs. Please see a list of current participating programs in the Program Overview and visit the program of interest in the Graduate Catalog to review the relevant requirements.

BUSINESS, EXECUTIVE BUSINESS RESEARCH

Kevin Carlson, Head

Professors: Alan Abrahams; Idris Adjerid; Rajesh Bagchi; Reza Barkhi; Daniel Beal; William Becker; Sudip Bhattacharjee; David Brinberg; Kevin Carlson; Dipankar Chakravarti; Eloise Coupey; Robert Davidson; Jason Deane; John Easterwood; Roger Edelen; Devi Gnyawali; Donald Hatfield; Paul Herr; Sean Hillison; Richard Hunt; Mohammad Jahan-Parvar; Tabitha James; Juncai Jiang; Gregory Kadlec; Raman Kumar; Wei Liu; Paul Lowry; John Maher; Frank May; Nancy McGehee; Juan Nicolau Gonzalbez; Mario Pandelaere; Richard Perdue; Cliff Ragsdale; Roberta Russell; Michelle Seref; Vijay Singal; Sarah Stein; David Townsend; Viswanath Venkatesh; Alan Wang; Anna Ward Bartlett; Richard Wokutch; Jin Xu; Pengfei Ye; Adam Yonce; Ryan Zimmerman; Christopher Zobel;

Associate Professors: Ling Lisic;

aombac@vt.edu: aombac@vt.edu

Graduate Site: <https://pamplin.vt.edu/academics/phd-programs/executive-phd.html>

Launched in 2016, the Ph.D. concentration in Executive Business Research serves experienced executives who seek the advanced knowledge and skills needed to conduct high quality research on critical issues facing the business community. This part-time program

challenges students to dive deeply into the scholarly literature and master advanced research methods in their chosen business discipline. Students blend this scholarly knowledge with their business experience to create high quality, original research embodied in a dissertation that addresses a complex business problem. Importantly, students develop the skills needed to publish their research in leading-edge research journals. Prospective students should plan a four to five-year commitment to build the credentials needed to earn this unique and rigorous Ph.D. degree. The academic demands in this unique part-time program are on par with that of Pamplin's full-time Ph.D. program in Business.

SPECIAL FACILITIES

The Ph.D. in Business: Concentration in Executive Business Research is offered at Virginia Tech's Northern Virginia Center. The center, which opened in 1997, is the university's primary teaching location for graduate programs in the National Capital Region. The 232,000-square-foot facility is located in the heart of Northern Virginia - just off Route 7 and I-66, adjacent to the West Falls Church Metro and next to George Mason High School. Virginia Tech Northern Virginia Center 7054 Haycock Road Falls Church, VA 22043

Northern Virginia Center

The Ph.D. in Business: Concentration in Executive Business Research is offered at Virginia Tech's Northern Virginia Center. The center, which opened in 1997, is the university's primary teaching location for graduate programs in the National Capital Region. The 232,000-square-foot facility is located in the heart of Northern Virginia - just off Route 7 and I-66, adjacent to the West Falls Church Metro and next to George Mason High School. Virginia Tech Northern Virginia Center 7054 Haycock Road Falls Church, VA 22043

DEGREES OFFERED

PhD Degree

Offered In (National Capital Region)

Credit Requirements: The Virginia Tech Ph.D. in Business requires a minimum of 90 credit hours. The program for the Executive Business Research concentration assumes prior graduate study in business or a related field from which a maximum of 30 relevant credits can be transferred to meet core credit requirements. Candidates without this preparation must complete an additional 30 credits of preparatory work. The remainder (a minimum of 60 credits) will include at least 30 credits of graded coursework (disciplinary/interdisciplinary and methodology seminars) and a minimum of thirty research/dissertation credits. **Graded Coursework:** The graded coursework is tailored to the student's primary disciplinary interest (corresponding to the six traditional concentrations offered at the Pamplin School: Accounting and Information Systems, Business Information Technology, Finance, Hospitality & Tourism, Management and Marketing). The first two disciplinary content seminars parallel those taken by traditional full-time Ph.D. students. The remaining (two or more) content seminars provide additional disciplinary depth or interdisciplinary content tuned to the student's research interests. These disciplinary seminars meet on weekday evenings or Friday afternoons. The methodology seminars meet on weekday evenings or Saturday mornings or afternoons. These meeting times (outside of normal work hours) allow executive Ph.D. students to participate synchronously with

traditional doctoral students in live discussion (either face-to-face or via Zoom technology). Students will have access to faculty/tutors in all methodology courses to support their academic work. The microeconomics review and the business pedagogy course meet during the winter terms of the first and second year, respectively. The module on scholarly ethics, diversity and inclusion is completed during the Spring term of the first year. The fall and spring terms during years 1 and 2 use a hybrid delivery format. Classes meet each week, with every other week being a residential session usually held at Virginia Tech's extended campus in Northern Virginia. Typically, three of these residential sessions meet in Blacksburg. These mandatory residential sessions help the Executive Ph.D. student assimilate into the Pamplin community and facilitate face-to-face interactions with faculty, potential research mentors, peer doctoral students, and academic tutors who support coursework. During Year 1, students should plan on attending approximately 23 residential sessions (Fall: 8; Winter: 2; Spring: 8; Summer: 5). In Year 2, there are 18 residencies (no summer residencies). In Year 3, when students are working on their dissertation proposals there are only four residencies (Fall: 2 and Spring: 2). No formal residencies are planned thereafter. During this period, students are strongly encouraged to communicate regularly and substantively with their Ph.D. Dissertation Committees. The Study Plan for the program lays out the registration schedule for the research and dissertation (R&D) credits. In Year 1, students register for 3 R&D credits (the summer proposal). In Year 2, students register for 7 R&D credits to initiate work on research papers as well as their dissertation proposal. Students in Year 3 register for 20 R&D credits during which they work on their dissertation proposal (and defense). Thereafter, as they work on their dissertations, students register for only 3 R&D credits in each of the Fall and Spring semesters. A minimum of 30 R&D credits must be accumulated during the program. Note that in Year 3, each student has an opportunity to obtain teaching experience. This may involve teaching an online or face-to-face graduate or undergraduate class in Pamplin. This experience is essential for gaining the pedagogical skills integral to a Ph.D. degree. **Research:** The emphasis on the creation and publication of high-quality scholarly research in the Virginia Tech Ph.D. concentration in Executive Business Research mirrors the heavy emphasis on research in our fulltime Ph.D. programs. The program also stresses participation in research conferences as part of the student mentoring and career development process. Even as the disciplinary and methods seminars focus on the research literature, the following activities create an early and sustained emphasis on first-hand student involvement in the scholarly research process: **YEAR ONE** Each student must write a research proposal/ paper by the end of the first summer. Along with the disciplinary content seminar assignments, this paper aims to stimulate and test students' ability to blend their formal academic training and business experience to develop a research proposal that addresses an important business problem. This proposal serves as the student's qualifying examination and is evaluated by a three-member reading committee who provide feedback similar to a journal review. **YEAR TWO** In addition to the stipulated coursework, students work with their faculty advisory committee to develop the above proposal (or one or more other promising ideas) into a paper(s) for presentation at a research conference and/or submission for publication review to a quality journal. Often, this proposal is developed further as a basis for the student's dissertation research. By the end of the summer term of their second year, students are expected to progress to the point where they can identify likely future mentors and form a Ph.D. Advisory Committee. **YEAR THREE** Students work closely with their Ph.D. Advisory Committee to develop the dissertation proposal. Students are expected to defend their respective dissertation proposals by the end of the summer of their third year in the program. The proposal defense meets the Graduate School's requirement for student's preliminary

examination. Students who successfully defend their dissertation proposal move to complete their dissertation research under the guidance of their Ph.D. Dissertation Committee. YEAR FOUR (AND BEYOND) Students work closely with their Ph.D. Dissertation Committee to complete the dissertation research. The dissertation is defended orally in a final examination and the written dissertation document is filed with the Graduate School once the student has met the expectations of the Ph.D. Dissertation Committee. Regular and substantive communications with the committee (particularly the chair/co-chairs) is critical to timely completion of the dissertation. The dissertation defense meets the student's final examination requirement for the VT Graduate School.

COMPUTATIONAL TISSUE ENGINEERING

Padmavathy Rajagopalan, Program Director

Professors: Padmavathy Rajagopalan;

Chemical Engineering: Padmavathy Rajagopalan;

Dr. Padma Rajagopalan: padmar@vt.edu

Graduate Site: <http://cte.cs.vt.edu/about-cte>

Graduate Site: <https://cte.cs.vt.edu/>

The goal of this interdisciplinary graduate education program is to define the field of Computational Tissue Engineering (CTE), wherein seamlessly intertwined computational and experimental models will drive the next generation of advances in tissue engineering. Our vision is that predictive computational models will drive novel experimental analyses of engineered tissues, while the demands of tissue engineering will inspire novel analysis frameworks in computational science. We will train students at the confluence of tissue engineering, molecular and cell biology, and computational science. Our vision is that trainees will emerge as the leaders of the trans-disciplinary field of "Computational Tissue Engineering". They will be equipped to lead and develop this new field, have the training to span traditional disciplinary boundaries, and to converse in the languages of tissue engineering, molecular and cellular biology, and computational science with ease. These students will be well-equipped to address the current challenges faced by each of these fields.

SPECIAL FACILITIES

This is an interdisciplinary program and shares facilities among departments across campus. Colleges and Departments: College of Engineering Chemical Engineering Computer Science Biomedical Engineering and Mechanical Industrial Systems Engineering Mechanical Engineering College of Science Biological Sciences, Statistics College of Agriculture and Life Sciences Biochemistry College of Veterinary Medicine Biomedical Sciences and Pathobiology College of Liberal Arts and Human Sciences Science and Technology in Society Biocomplexity Institute For more information please contact: Professor Padma Rajagopalan, Program Director, padmar at vt dot edu

Facilities

This is an interdisciplinary program and shares facilities among

departments across campus. Colleges and Departments: College of Engineering Chemical Engineering Computer Science Biomedical Engineering and Applied Mechanics Industrial Systems Engineering Mechanical Engineering College of Science Biological Sciences Statistics College of Agriculture and Life Sciences Biochemistry College of Veterinary Medicine Biomedical Sciences and Pathobiology College of Liberal Arts and Human Sciences Science and Technology in Society Biocomplexity Institute

DEGREES OFFERED

IGEP Degree

Offered In (Blacksburg)

TOEFL

Paper: (550.0)

iBT: (80.0)

CTE students will obtain their Ph.D. degrees from a parent department or program, from among the several that CTE faculty are affiliated with. When you apply to the Graduate School at Virginia Tech, please be sure to specify from which department you seek to obtain a Ph.D. Typically, a CTE student identifies a CTE faculty member during the admissions and recruitment process. After the student joins Virginia Tech, she can consult the advisor and identify another faculty member to serve as a co-advisor. We strongly encourage students to work with advisors spanning at least two of the three areas at the core of CTE (tissue engineering, computational science, and systems biology) and to include committee members in the third area.

CREATIVE TECHNOLOGIES

Amy Kirschke, Head

Professors: Kevin Concannon; Eric Standley;

Associate Professors: Samuel Blanchard; Meaghan Dee; Travis Head; Thomas Tucker;

Assistant Professors: Michael Borowski; Zachary Duer; Lesley Duffield; Patrick Finley; Nathan King; Kathleen Meaney; Wallace Santos Lages; Rachel Weaver;

General Contact: rcallah@vt.edu

Graduate Contact: duffles@vt.edu

Graduate Contact: rlw@vt.edu

Creative Technologies MFA Program: <http://www.sova.vt.edu/creative-technologies-mfa/>

School of Visual Arts: <http://www.sova.vt.edu/>

The Master of Fine Arts (MFA) in Creative Technologies (CT) in the School of Visual Arts (SOVA) is a practice-focused, terminal degree program at the intersections of fine art, design, and technology.

artistic works and research with the support of faculty mentorship amidst a diverse community of peers. Our MFA program is fundamentally cross-disciplinary and equips students with the conceptual, technical, creative, and critical skills to be successful artists and leaders across a range of fields. MFA student practices reflect the individual research interests of each student. Approaches to investigation span a remarkable spectrum of inquiry across art, design, and computing, from coding, virtual environments, 3D modeling, and interactivity, to video art, projection mapping, experimental animation, expanded sculpture, and a myriad of other unbounded creative modalities. Research trajectories for MFA students may also be informed by other programs across the university at the intersection of the arts, design, humanities, media, sciences, engineering, and culture. On average, full-time enrolled MFA students will complete the program in four semesters or two full academic years. Application Deadline Our program's standard application deadline is January 15, for Fall admission only. We highly encourage interested applicants to contact program coordinators to resolve any uncertainties or questions before applying. Please refer to the School of Visual Arts MFA program website for more information, and here for additional specific application instructions.

SPECIAL FACILITIES

The School of Visual Arts facilities are located in several different buildings on the Virginia Tech Blacksburg Campus. The Armory Building (203 Draper Rd. NW) is home to the school's main office, gallery, and classrooms utilized for Drawing and the Foundations Programs. Located downtown, the Armory provides a lively intersection of the town and campus. The Armory Art Gallery is operated as an educational and outreach service of the University. Its exhibition calendar includes work by visiting artists, faculty, and students. Additional core facilities that support MFA courses and student work include the following: The Art & Design Learning Center (ADLC) is the location for SOVA studios in Painting, Photography, and Sculpture. The Sculpture studio maintains a strong focus on digital fabrication/prototyping and also includes a full wood shop, welding supplies, and CNC Router / Laser Cutter. The Media Building, located centrally downtown, is occasionally utilized for School of Visual Arts classrooms, and provides unique opportunities for collaboration and exhibition. Digital Arts and Animation Lab (DAAS), centrally located on the first floor of the Newman Library. The lab contains a render farm as well as numerous computers configured with professional software to facilitate creative production across digital arts and media technologies. ICAT Box, (CTBOX) located adjacent to DAAS on the first floor of the Newman Library, this lab additionally contains computers and software as well as VR headsets and other equipment for immersive and interactive media development. Henderson Hall houses the offices of numerous SOVA faculty, classrooms for the Graphic Design program (undergraduate) and Art History, as well as classrooms utilized by the Creative Technologies program. Four Design (SOVA's undergraduate professional design internship program) is also located in Henderson. Equipment and Tools accessible to MFAs who have received permission and requisite training include items such as the following: 3D Laser Scanner Flatbed Scanners CNC Router 3D Printers Laser and Inkjet Printers Laser Cutters VR Headsets VR-Ready Computers HD and 4K Digital Projectors Plasma, HD and 4K Monitors DSLR and Digital Video Cameras 16mm Cameras Tripods, Lighting Kits, Projector Stands Digital Audio Recorders Media Players Soldering supplies Small electronics, sensors, microcontrollers College-level facilities include the Art + Architecture Library located in Cowgill Hall. Additionally, MFA students may be able to undertake research projects through ICAT, which can facilitate access to specialized equipment and production spaces. These include labs equipped and dedicated to innovative and experimental arts and technology research projects.

Within ICAT, these labs include the Cube, Experience Studio, Sandbox, Learn Studio, Perform Studio, and Create Studio. All Virginia Tech students additionally have access to well-equipped public digital laboratories facilitated by the University Libraries, including the various Media Design Studios, which are spaces for all members of the Virginia Tech campus community to create or co-create various types of media, including video, audio, and other multimedia, and access or check out high-end technology. This suite of options includes: The Virtual Environments Studio (VR production) The 3D Design Studio (3D printing) The Data Viz Studio (a data visualization lab) The Fusion Studio (co-working/ brainstorming and prototyping space)

Facility Web Resources

See the links below regarding a range of facilities and resources currently utilized by the School of Visual Arts at Virginia Tech.

DEGREES OFFERED

MFA Degree

Offered In (Blacksburg)

IELTS

TOEFL

Paper: (550.0)

iBT: (80.0)

The MFA in Creative Technologies requires the accumulation of 60 graduate credit hours over approximately four semesters of full-time enrollment. Graduate credit hours should be distributed as follows: * 15 credit hours in applied studio courses across SOVA 12 minimum additional credit hours in studio courses or ART 5994 Research and Thesis. Students may supplement these credits with graduate-level courses in other departments, so long as these are approved by advisors and appropriate to student's area(s) of research 9 minimum credit hours in Art History/Theory courses, including ART 5854G Advanced Theories and Processes of Contemporary Art (3 credit hours). Ethics must be a required component of at least one of these courses. 12 credit hours in ART 5534 Graduate Art Critique or Graduate Studio / Seminar courses 12 credit hours in ART 5594 Research and Thesis *Note: MFA students may be required to take supplemental courses to strengthen their background in specific areas as determined necessary by MFA Program Director. These courses may not count towards the 60 hour Plan of Study, but may count toward full-time enrollment status. Additionally, The Creative Technologies MFA requires the development, completion, and successful defense of an original creative thesis and research project. The MFA student works closely with their MFA Thesis Committee during their final two semesters in the program, and the Thesis Committee oversees and assesses student efforts in this capacity. Note that the MFA Thesis committee must include at least three SOVA faculty. The student's creative work is exhibited and defended during the last half of the student's final semester in the MFA program. The student must additionally complete and submit a written Electronic Thesis and Dissertation before receiving approval from the Committee.

Degree Concentrations:

Rather than pre-defined curricular tracks, Creative Technologies MFA

students work with their faculty and assigned Graduate Program Advisor(s) to develop an individualized Plan of Study. All continuing students enroll in Graduate Critique courses to better strengthen the development of the MFA community, along with facilitating opportunities for invaluable peer and faculty critique. They additionally enroll in a range of differing studio, history/theory, and research-driven courses that cumulatively support the actualization of each student's unique intellectual and artistic goals.

DATA ANALYSIS AND APPLIED STATISTICS

David Higdon, Head

Professors: Ronald Fricker; Robert Gramacy; Feng Guo; David Higdon; Ina

Hoeschele; Yili Hong; John Morgan; Sally Morton; Eric Smith; Gordon Vining;

Associate Professors: Xinwei Deng; Pang Du; Marco Ferreira; Leanna House;

Leah Johnson; Inyoung Kim; Scott Leman; George Terrell; Xiaowei Wu; Hongxiao Zhu;

Assistant Professors: Christopher Franck; Shyam Ranganathan; Srijan Sengupta;

Associate Professor of Practice: Jennifer Van Mullekom;

Research Assistant Professors: Allison Tegge;

Collegiate Associate Professors: Anne Driscoll;

Graduate Contact: epsmith@vt.edu

General Contact: chconne1@vt.edu

Graduate Site: <https://www.stat.vt.edu/Academics/graduate/ma-curriculum.html>

The Master of Arts in Data Analysis and Applied Statistics is offered by Virginia Tech's Department of Statistics. The degree is also sponsored by other programs and departments including the Education Research and Evaluation Program (EDRE), the Departments of Psychology, Fish and Wildlife Conservation, Forest Resources and Environmental Conservation, Geography, Economics, Human Development, Sociology, Psychology, Biological Sciences, and the Genetics, Bioinformatics, and Computational Biology program. The curriculum provides a broad variety of applied statistical tools to students, without the emphasis on statistical theory steeped in mathematics. The M.A. DAAS degree is structured so that certain courses that emphasize the fundamentals of statistics, are required. Electives in specialized topics in statistics are then chosen by the student. Thus, the degree offers sufficient depth in the fundamentals of contemporary applied statistical methods and gives students an understanding of how these methods are applied in different fields. Students seeking admission to the M.A. DAAS degree are those wishing to expand their statistical knowledge beyond the material presented in graduate service courses, tackling more specialized topics, whether they are taught statistical methodology by the Department of Statistics or by other programs/departments on campus. The M.A. DAAS degree is offered as a simultaneous degree. Current Virginia Tech master's and/or Ph.D. students in another discipline, who desire to complement their training with the M.A. DAAS degree, are eligible to apply to the degree. The applied statistics emphasis of the M.A. DAAS will empower students

to perform more statistically sophisticated research, improving the quality of their theses/dissertations, and leading to papers published in higher level journals than would be possible without such courses.

SPECIAL FACILITIES

Department of Statistics

The department has several laboratories housing state-of-the-art Linux and PC networks. Students have access to these for collaboration, course work, and research. Students gain extensive experience with modern statistical software for experimental design, data management and analysis, and computer programming for statistical purposes.

DEGREES OFFERED

MADAS Degree

Offered In (Blacksburg, National Capital Region)

The program requires 33 credit hours of coursework (21 hours from the core and 12 hours of electives). The core requirements will be based on courses from four topic areas: Data Analysis, Design of Experiments or Study Design, Regression Analysis, and Statistical Theory, and also a professional development course in consulting. Below is a list of the core courses: STAT 5615: Statistics in Research I STAT 5616: Statistics in Research II STAT 5204G: Experimental Design: Concepts and Application STAT 5214G: Advanced Methods of Regression Analysis STAT 5105G: Theoretical Statistics STAT 5024: Effective Communication in Statistical Consulting STAT 5904: Project and Report

DISASTER RESILIENCE

Professors: Jennifer Irish; Marie Paretti; Robert Weiss; Christopher Zobel;

Associate Professors: Margaret Cowell; Yang Zhang;

R.B. Pamplin Professor of Business Information Technology: Christopher Zobel;

General Contact: czobel@vt.edu

Graduate Site: <http://www.czobel.bit.vt.edu/resilience-igep/index.html>

Interdisciplinary efforts to build resilience to disasters have not succeeded as desired. Although we now have better models, better technology and better communication, our vulnerability to disaster and risks continues to grow. One of the key reasons for this is the way we live. Concentrations of people, power, technology, education, and knowledge lower resilience and create more complex connections that can be disrupted. Virginia Tech's Interdisciplinary Graduate Education Program in Disaster Resilience is working to improve disaster resilience and sustainability by changing the interdisciplinary paradigm. Instead of feeding information and experience into a core of knowledge, the Disaster Resilience IGEP's goal is to have the disaster perspective inform the disciplines. We are tapping the power of scenarios to create a

shared experience among many disciplines. This experience will help shape a perspective of resilience that informs everyday decisions in widely distributed activities. The primary goal of our collaborative effort is to prepare graduate students to become thought leaders in promoting resilience concerns in a wide variety of disciplines. Focusing on the trans-disciplinary paradigm, our effort leverages the strengths of several world-class academic units at Virginia Tech to produce a well-rounded perspective and understanding of the full complexity of disaster risk, resilience, and mitigation. Our approach concentrates on investigating the main drivers of vulnerabilities, recognizing their complex interactions, and generating informed risk minimization strategies. The current departments and colleges at Virginia Tech from which the core faculty in the program are as follows: Business Information Technology (in the College of Business) Civil and Environmental Engineering (in the College of Engineering) Geosciences (in the College of Science) Urban Affairs & Planning (in the College of Architecture and Urban Studies) Engineering Education (in the College of Engineering) New students can be admitted directly into the Interdisciplinary Graduate Education Program in Disaster Resilience, but they will transition into one of the participating academic departments for their core coursework and degree completion, while continuing to participate in Program activities. The Disaster Resilience program does not currently offer a dedicated graduate degree.

SPECIAL FACILITIES

DR IGEP facilities correspond to those available to each of the faculty members in their home departments.

DEGREES OFFERED

IGEP Degree

Offered In (Blacksburg, National Capital Region)

The Interdisciplinary Graduate Education Program in Disaster Resilience does not currently offer a dedicated graduate degree. Participants will participate in interdisciplinary program activities such as seminars and workshops, but will work towards receiving a PhD degree from one of the following core participating departments: Business Information Technology (in the College of Business) Civil and Environmental Engineering (in the College of Engineering) Geosciences (in the College of Science) Urban Affairs & Planning (in the College of Architecture and Urban Studies)

HIGHER EDUCATION

Claire Robbins, Program Director
D Chase Catalano, Interim Program Director

Emeriti Faculty: Joan Hirt; Steven Janosik;

Associate Professors: Claire Robbins;

Assistant Professors: D Chase Catalano; Tonisha Lane;

Affiliated Faculty: Catherine Amelink; Jennifer Bondy; Jennifer Case; John Dooley; Martha Glass; Michael Herndon; Patricia Hyer; David Knight; David Kniola; Walter Lee; Sarah Ovink; Ellen Plummer; Menah Pratt-Clarke; Donna Ratcliffe; Karen Sanders; Susan Short; Frank Shushok; Kimberly Smith; Kenneth Smith; Edward Spencer;

Assistant Professor of Practice: Sharrika Adams;

General Contact: nanboden@vt.edu

Higher Education: <http://www.soe.vt.edu/highered/>

The Higher Education program at Virginia Tech is built upon collegial relationships between faculty and students throughout the period of graduate study. Faculty serve as teachers, advisors, colleagues, and mentors to students in our Ph.D., M.A.Ed., and Certificate programs.

Program Highlights Focus on preparing leaders for postsecondary education who use and produce high-impact research as part of their practice and who are committed to service in both professional and personal contexts Small cohorts and high student/professor interaction Opportunities for student scholarship and research Capstone ePortfolio experience for students in the master's program Graduate assistantships and tuition waivers available for full-time master's and doctoral students A commitment to diversity Part-time and certificate enrollment for working professionals Program Director, M.A.Ed. Program: Sharrika D. Adams, Ph.D., Assistant Professor of Practice 1750 Kraft Drive, Room 2015 Blacksburg, VA 24060 540-231-5872 davissd@vt.edu Program Director, Ph.D. and Certificate Programs: Claire K. Robbins, Ph.D., Associate Professor (on research leave Fall 2020-Spring 2021) 1750 Kraft Drive, Room 2007 Blacksburg, VA 24060 540-231-2004 robbinsc@vt.edu Graduate Program Director: Dr. Nancy Bodenhorn, Associate Director, Office of Academic Programs, School of Education 540-231-8180 nanboden@vt.edu Please access our website for more information about our Ph.D., M.A.Ed., and Certificate programs.

SPECIAL FACILITIES

Faculty members in the Higher Education program hold offices in Suite 2000 of the building located at 1750 Kraft Drive, Blacksburg, Virginia 24060. This building is situated in the Corporate Research Center, opposite the airport and just off Research Center Drive.

DEGREES OFFERED

MAEd Degree

Offered In (Blacksburg)

TOEFL

Paper: (577.0)

iBT: (90.0)

The Higher Education Program offers the M.A.Ed degree only on the Blacksburg campus. Please refer to the program website for specific requirements.

PhD Degree

Offered In (Blacksburg)

TOEFL

Paper: (577.0)

iBT: (90.0)

The Higher Education Program offers the Ph.D. degree only on the Blacksburg campus. Please refer to the program website for specific requirements.

GRADUATE COURSES (EDHE)

EDHE 5105:

Assessment in Higher Education Administration

EDHE 5105: Theoretical, practical, and policy issues in the assessment of student learning outcomes. Principles for evaluation of co-curricular or higher education-related programs, services, or facilities. Assessment of student learning outcomes in those programs and activities. Pre: Graduate standing. EDHE 5106: Application of theoretical, practical, and policy issues in professional education settings such as administrative or service delivery department in higher education. Development of assessment plans, collection and analysis of data, evaluation of findings, and preparation of final assessment reports. Pre: 5105.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

EDHE 5106:

Assessment in Higher Education Administration

EDHE 5105: Theoretical, practical, and policy issues in the assessment of student learning outcomes. Principles for evaluation of co-curricular or higher education-related programs, services, or facilities. Assessment of student learning outcomes in those programs and activities. Pre: Graduate standing. EDHE 5106: Application of theoretical, practical, and policy issues in professional education settings such as administrative or service delivery department in higher education. Development of assessment plans, collection and analysis of data, evaluation of findings, and preparation of final assessment reports. Pre: 5105.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): EDHE 5105

Corequisite(s):

EDHE 5284:

Practicum in Higher Education

Supervised work experience within a higher education setting. Application of classroom knowledge to the workplace setting in higher education including assessment and evaluation, program development and execution, research, personal development and career planning. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

EDHE 5304:

Introduction to the Student Affairs Profession

History, philosophy, and goals of the student affairs profession in American higher education. Standards and contexts for student affairs, including scholarly literature related to students and student organizational culture, ethical principles, and professional and quality standards. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

EDHE 5314:

Theories of College Student Development

Theories of college student development. Foundational, integrative, and social identity theories, fundamental criticisms of well-known student development theories, identification of current student populations affected, and applying theories to student affairs practice and personal development. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

EDHE 5334:

The American College Student and the College Environment

Study of the characteristics and attitudes of traditional and nontraditional college students; effect of the college environment on students.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

Staffing Practices in Higher Education

Study of human resource management in education. Emphasis on recruitment and selection, orientation, supervision, staff development, performance appraisal, and separation. Application of a human resource development perspective guides research and assessment of current and future practices. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

EDHE 5604:**Graduate Seminar in Education**

Selected topics in administration, counseling, adult and continuing education, research and evaluation, and community college and other domains of higher education. Emphasis is on interactive discourse on topics not typically included in regularly scheduled courses. (Maximum 3C per course).

Credit Hour(s): 1 TO 3

Lecture Hour(s): 1 TO 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

EDHE 5974:**Independent Study**

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Independent Study, VI

Instruction Type(s): Independent Study, VI

Prerequisite(s):

Corequisite(s):

EDHE 5984:**Special Study**

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

EDHE 5994:**Research and Thesis**

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research

Instruction Type(s): Research

Prerequisite(s):

Corequisite(s):

EDHE 6044:**Governance and Policy in Education**

Antecedents of public policy affecting education in the United States, and the relationships between policy making and implementation and educational administration.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

EDHE 6054:**College and University Administration**

Advanced graduate study of the governance and administration of the modern, contemporary university in the United States with a focus on the research literature in the field.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

EDHE 6064:**Higher Education in the United States**

Diversity of institutions of higher learning is examined through variations in the respective goals and purposes of distinct types of institutions and examined through variations in the constituencies served by different types of institutions and their differential impact on students and faculty.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

EDHE 6084:**Financial Administration in Higher Education**

Financing higher education. Emphasis on examination of the revenue source and patterns of funding and the roles of federal, state, and local governments in the fiscal support of higher education. Methods for the determination of institutional resource allocation, program and financial planning, and the internal allocation and effective use of resources.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

EDHE 6094:**Educational Administration Processes and Skills**

College and university leadership and administration. Focus on executive leadership, governance, development, research, outreach and engagement. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

EDHE 6114:**Staffing Practices in Education**

A study of human resource management in education. Emphasis will be given to recruitment and selection, induction and orientation, supervision, staff development, and performance appraisal practices at all levels of education. Doctoral standing or instructor permission is required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

EDHE 6304:**Theories of Educational Organizations**

Study of educational organization theory and behavior. Emphasis will be given to understanding institutional structures and cultures in their educational, social, economic, and political contexts with a view toward organization improvement, development, and reform.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

EDHE 6404:**Higher Education Research Proposal Design**

Conceptualize and write elements of a research proposal suitable for a doctoral dissertation including topic selection, literature reviews, conceptual frameworks, research questions/hypotheses, and select research techniques appropriate for gathering data. Pre: EDRE 6605, EDRE 6606, and EDRE 6524.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): EDRE 6605, EDRE 6606, EDRE 6524

Corequisite(s):

EDHE 6424:**Institutional Effectiveness and Outcome Assessment in Higher Education**

Study of institutional conditions that determine effectiveness including effects of institutions on student learning and personal development. Includes assessment of general education, the academic major, affective student learning, retention, employment suitability, and other aspects of student life related to teaching and learning.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

EDHE 6984:**Special Study**

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

EDHE 7704:

Advanced applied research and/or evaluation study in one or more educational institutions or agencies. The student is graded on the basis of the design of the study and ability to conduct the study and report the results. (Maximum 12C).

Credit Hour(s): 1 TO 12

Lecture Hour(s): 1 TO 12

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

EDHE 7714:

Internship in Education

Planned program of advanced clinical practice in education through assignment under direct supervision of outstanding practitioner for periods of up to two semesters. (Maximum 24C).

Credit Hour(s): 1 TO 24

Lecture Hour(s): 1 TO 24

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

EDHE 7994:

Research and Dissertation

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research, Online Research

Instruction Type(s): Research, Online Research

Prerequisite(s):

Corequisite(s):

HUMAN CENTERED DESIGN

Ivica Bukvic, Program Director

Donald McCrickard, Program Director

Associate Professors: Ivica Bukvic; Donald McCrickard; Matthew Wisnioski;

Associate Professor of Practice: Steven Harrison;

General Contact: ico@vt.edu

General Contact: mccricks@cs.vt.edu

Graduate Site: <http://www.hcd.icat.vt.edu>

Design matters. The act of creating something new shows up in many

human endeavors. It can be a solution to a mundane problem like holding sheets of paper together or something as complex as the formulation of new institutions. Human Centered Design (HCD) is an approach to design charged with understanding the needs, wants, and limitations of end-users. This is accomplished through methodologies and practices where these considerations are integrated at every stage of the design process. HCD creates novel learning and discovery opportunities that are needed to train the future professoriate, workforce, professionals and civic leaders. HCD can only be taught in a true interdisciplinary educational environment in which coursework and research embrace diversity, inclusiveness, educational breadth, and interdependence, while promoting a person-oriented, rather than a product-oriented, attitude towards education. HCD at VT provides access to both doctoral degree programs and a graduate certificate program in curricula that combine technical expertise with critical inquiry to develop reflective practitioners equipped to meet vital human needs. The HCD/IGEP program is built around competencies in four core areas: (1) Interdisciplinary Research, (2) Design Studies, (3) Understanding People, and (4) Design Realization. Faculty currently associated with the HCD program are from these Colleges and Departments: College of Architecture & Urban Studies Industrial Design School of Visual Art College of Engineering Computer Science Electrical and Computer Engineering Engineering Education Industrial Systems Engineering Mechanical Engineering College of Liberal Arts and Human Sciences English Human Development Learning Sciences and Technology – School of Education Science and Technology in Society Music – School of Performing Arts Theater and Cinema – School of Performing Arts College of Natural Resources and Environment Geography Forest Resources Institute: Institute for Creativity, Art, and Technology (ICAT) For more information please contact Scott McCrickard (mccricks@cs.vt.edu) or Ivica Bukvic (ico@vt.edu)

SPECIAL FACILITIES

Investigations in Human-Centered Design may take the form of creative production, hypothesis-driven research, or phenomenological enquiry. The field's intrinsic interdisciplinarity draws on facilities from around Virginia Tech – from the studio labs of ICAT to the usability labs of CHCI.

CHCI

CHCI: The Center for Human-Computer Interaction The Center for Human-Computer Interaction provides access to a large and diverse set of facilities, software, and equipment. The infrastructure includes a large shared laboratory (the "Black Lab" in VT Knowledgeworks II), a usability lab (in McBryde Hall), Virtual Reality laboratory (the "Sandbox" in the Moss Art Center), secure data transcription and coding labs, several smaller laboratories or project rooms, and meeting rooms. The equipment inventory includes both large fixed assets, such as the Gigapixel Display and the Optitrack motion capture system, and a wide array of portable items such as tablets, cameras, and eye trackers that are available to students and faculty associated with the Center. The Center gratefully acknowledges the support of the National Science Foundation in acquiring this infrastructure. Jointly with ICAT, the Center will be creating educational and community studio spaces in the Media Arts Building.

DAAS

DAAS : Digital Arts and Animation Lab The new Digital Arts and

Animation Lab (DAAS) is centrally located in Blacksburg's downtown area. This facility provides students with the high-end tools used throughout industry in the production of digital film, web, and animation content. The lab contains 16 Mac Pro workstations with large 23-inch monitors and loaded with professional industry applications, like Final Cut Pro and Maya. The facility also has an additional small render farm of six 12-core Mac Pros and a state-of-the-art ABS Rapid Prototyper, used for outputting virtual models into Three-Dimensional forms for research and educational purposes.

DISIS

DISIS: Digital Interactive Sound and Intermedia Studio

DISIS complements and recontextualizes the Virginia Tech music technology program by providing the rapidly growing Creative Technologies in Composition and Multimedia Art Design option. By coupling contemporary technology with traditional performance idioms, DISIS pursues a symbiosis of new forms of artistic expression with special focus on interactive multimedia art and scientific research of new multimedia technologies for the purpose of betterment of the overall quality of life.

ICAT

ICAT: Institute for Creativity, Arts, and Technology Located at the very crossroads of Virginia Tech and downtown Blacksburg, on the corner of Main Street and Alumni Mall, the Center for the Arts' facilities provide a community center in the grandest sense, a place where the arts are a catalyst for engagement, inspiration, and discovery. New facilities complement existing venues, and are located in close proximity to Henderson Hall, Theatre 101, Squires Student Center, the Armory Gallery, and the Lyric Theatre forming a prominent arts district. The center's 150,000-square-foot facility includes the four-story experimental "Cube" for performance, immersive environments, installation, and adjacent research studios. Prototyping and multimedia studios provide resources for material exploration and performance. Jointly with the Center for HCI and the Creativity and Innovation SGA, the Institute will be creating educational and community studio spaces in the Media Arts Building.

DEGREES OFFERED

IGEP Degree

TOEFL

Paper: (550.0)

iBT: (80.0)

GRE

General: Verbal, Quantitative, Analytical

Graduate students affiliated with the HCD IGEP may pursue a PhD in one of the home departments of HCD-associated faculty or may elect to apply to the Graduate School's Individualized Interdisciplinary PhD (IPhD) degree program. IPhD students are expected meet all

requirements for doctoral study at Virginia Tech, but are able to craft a unique program of study, uniting multiple disciplines, advisors, and coursework to best satisfy their scholarly interests and career aspirations. Doctoral degrees require 90 credits of graduate course work and research beyond the bachelor's degree. Graduate credits earned in pursuit of a master's degree may be included in the doctoral plan of study if they meet the Graduate School's transfer credit criteria and are approved by the student's advisory committee. For example, students who earned a master's degree at Virginia Tech (minimum of 30 credits) that included coursework and research relevant to their plans for the IPhD would complete another 60 credits for this doctorate. IPhD students who earned a master's degree at another accredited university could transfer up to 50% of the required graded coursework to their IPhD plan of study (required graded coursework could range from 27 to 60 credits). It is expected that IPhD students will be enrolled full time for the duration of their doctoral studies. All students will complete a common core comprising three categories of courses: (1) Overview of interdisciplinary studies, (i.e., GRAD 5134, Topics in Interdisciplinary Studies), (2) Research Methods and Data Analysis and Interpretation, and (3) Scholarly and Professional Ethics. In addition, all ID PhD students will complete graduate coursework in relevant disciplinary areas and research and dissertation credits: (4) Disciplinary Studies – list the courses by academic area; total number of credits will vary. The minimum number of graded course credits is 27. See graduate program website for current CORE Disciplinary Study approved cognate courses. (5) Research and Dissertation - the minimum number of research and dissertation credits is 30. Students' IPhD proposals are developed in consultation with their major professor, advisory committee members, and the IPhD Program Director. Proposals are reviewed and approved by the Commission on Graduate and Professional Studies and Policies (CGPSP). The student's advisory committee works with the student to design a plan of study, approves the plan of study, provides advice, conducts required examinations and regularly assesses the student's progress and accomplishments. IPhD students must have an advisory committee of at least four faculty members representing at least two different disciplines.

INDIVIDUAL INTERDISCIPLINARY PHD

Karen DePauw, Head

Karen DePauw: kdpauw@vt.edu

General Contact: wrhuckle@vt.edu

Interdisciplinary graduate Education:

<http://interdisciplinary.graduateschool.vt.edu>

The Individual Interdisciplinary Doctoral Program (IPhD) is designed to prepare exceptional graduate students who wish to pursue and attain an individually customized interdisciplinary doctoral degree. The purpose of the IPhD is to provide an option for highly qualified students whose educational goals are uniquely interdisciplinary and cannot optimally be met by a single discipline or degree-granting academic unit at Virginia Tech. The IPhD offers a distinctive opportunity for students seeking a breadth of knowledge, in addition to disciplinary depth, not available within one discipline.

SPECIAL FACILITIES

567 The IPhD program is housed in the Graduate School located in the

Graduate Life Center. Additional facilities may be available depending on those available to the advisory committee members.

Graduate Life Center

The IPhD is housed administratively in the Graduate Life Center.

Facilities available to IPhD students will depend on those available to the advisory committee members and the nature of the research.

DEGREES OFFERED

PhD Degree

The Graduate School offers the individualized interdisciplinary PhD (IPhD) program for highly motivated students in excellent academic standing whose primary education and research goals are truly interdisciplinary and not readily accommodated by a single existing discipline. The IPhD program is specifically designed for students who seek to study across two or more disciplines in a combination not available through a conventional degree-granting program. For successful admission to and completion of the IPhD program at Virginia Tech, the student must demonstrate the need for an interdisciplinary research program and identify a major professor and advisory committee members who will provide the appropriate guidance. The composition of the advisory committee should reflect the particular academic disciplines and realms of expertise being united by the IPhD program, but typically stems from the student's original programmatic affiliation(s). In identifying potential advisors and areas of study, prospective IPhD students may elect to craft a wholly unique degree focus and advisory team, or may affiliate with faculty participants in an existing Interdisciplinary Graduate Education Program (IGEP). For applicants to the IPhD program who are not currently enrolled as graduate students at Virginia Tech, it is essential first to identify a major professor and advisory committee members willing and able to serve in these capacities. Typically, this step will necessitate a visit to campus or extensive exploration by phone or email. Admission to the IPhD is highly selective. The Graduate School will expect completion of an especially rigorous set of courses and dissertation research project for this degree. Applicants most competitive for entry into an IPhD program are those nearing completion or having completed a master's degree. Prospective students without a master's degree may be approved by the Vice President and Dean of the Graduate School to submit an application under special circumstances. Because of the rigor and intensity of the IPhD program, a graduate GPA of 3.5 or higher is required. Students currently enrolled in a graduate degree program at Virginia Tech who are interested in the IPhD are encouraged to apply as early as possible in their program, to maximize the duration of their unique interdisciplinary training experience. Prospective IPhD students should contact Bill Huckle, Associate Dean and Director of Interdisciplinary Graduate Education by email (wrhuckle@vt.edu) for information and guidance in preparing the IPhD application. Candidates will prepare their application, including a program of study and dissertation proposal, in consultation with the major advisor, the advisory committee members, and the Graduate School. Formal applications for admission to the IPhD program are submitted to the Graduate School and are evaluated on a rolling basis. Once admitted, students can start their IPhD program in Fall, Spring, or Summer terms. The Commission on Graduate and Professional Studies and Policies (CGPSP) serves as the IPhD admissions committee and reviews applications during their twice-monthly meetings throughout the academic year. Application materials include the following: Results of standardized tests such as GRE or GMAT, if required by the academic units with which the student

principally will be working. For international students, acceptable TOEFL (iBT at least 80 total and 20 on each subtest) or IELTS (6.5) scores.

Other credentials can satisfy Graduate School requirements for competency in English (e.g., earned a degree from an international university that provides all instruction in English). A letter from a Virginia Tech faculty member identified as the student's IPhD program advisor, describing the student's potential for success and ability to conduct independent interdisciplinary research, and expressing willingness to chair the student's advisory committee. Letters or email messages from three or four VT faculty members willing and qualified to serve on the student's advisory committee. The committee should be comprised of faculty representing at least two colleges. For new applicants, three letters of recommendation from faculty commenting on the student's ability to pursue an interdisciplinary doctoral degree. For new applicants, at least one example of scholarly writing (e.g., introduction and conclusion of master's thesis, published research paper) Student's statement of career goals and rationale for pursuing the IPhD degree. An IPhD degree proposal document, not to exceed 20 pages in length, that includes the components indicated below. An example proposal document is available upon request. Proposed interdisciplinary degree program title. Advisor and list of advisory committee members, including rationale for their inclusion on the committee and identification of areas of expertise relevant to the proposed research program. Completed and current coursework (unofficial transcripts are acceptable). Coursework plan of study for the IPhD degree. Plan of study must include courses from multiple colleges and departments and must be distinct from plans of study of existing degree programs at Virginia Tech. A table including rationale for each course and their contribution to the interdisciplinary objectives should be included. Career goals and personal motivation for pursuing an IPhD. A description of the format and content of the preliminary examination, including topic areas to be covered from various disciplines involved and an assessment of the success of disciplinary integration. Detailed timeline from enrollment to graduation. A brief description of the research topic, methodology, and nature of the final product(s) that will constitute the archival manifestation of the IPhD work. The products should include, but need not be restricted to, a written document that explores the scholarly history and context of the interdisciplinary work. The proposal should be written with a general, interdisciplinary academic audience in mind. A short literature review along with a summary of objectives or anticipated products must be included. The description should make the case: 1) that the proposed project is truly scholarly in nature (i.e., worthy of an earned doctorate) and 2) that the proposed dissertation can best be accomplished from an interdisciplinary standpoint. The Graduate School does not provide funding to support students earning the IPhD. Students are encouraged to seek funding through faculty grants, departmental funds, and/or other funding opportunities such as IGEP programs, scholarships and fellowships from VT or external sources.

INFECTIOUS DISEASE

Xiang-Jin Meng, Head

Graduate Contact: ams@vt.edu

Graduate Contact: kjedgar@vt.edu

Graduate Site: <https://infectiousdisease.fralinlifesci.vt.edu/igep.html>

scholars. The ID program aims to advance knowledge of the biology of pathogens, vectors, and hosts, the science of prevention and treatment, as well as the environmental, social, and behavioral aspects of public health. The program will train PhD students that select to work in a home laboratory from the over 100 faculty members in six colleges and 31 departments affiliated with the Center for Emerging, Zoonotic, and Arthropod-borne Pathogens (CeZAP). Students participating in the ID IGEP will learn to: Tackle societal challenges related to infectious disease by integrating multiple diverse viewpoints Master technical skills necessary to solve complex ID research questions in a transdisciplinary manner Excel in coursework, while learning to apply strategies to predict and circumvent the risk of disease emergence affecting humans, animals and plants Communicate their research effectively to others outside of their field of study Participate as a member of a cross-campus ID community through activities such as poster sessions, research seminars and symposia that foster professional development Partner with agencies, industry and the public to address ID issues beyond Virginia Tech To learn more, including information on participating faculty members, areas of research focus, and the application process, please visit our website:
<https://infectiousdisease.fralinlifesci.vt.edu/igep.html>

SPECIAL FACILITIES

DEGREES OFFERED

IGEP Degree

Offered In (Blacksburg)

TOEFL

Paper: (577.0)

iBT: (90.0)

The Infectious Disease (ID) IGEP is not a degree-granting program. A student electing to affiliate with the ID program will be enrolled in the home degree program of one of the participating faculty members (typically their advisory committee chair) and will be expected to meet the prevailing degree requirements of that academic unit.

INTERFACES OF GLOBAL CHANGE

Dr. William Hopkins, Director: hopkinsw@vt.edu

Dr. Bruce Hull, Committee Chair: hullrb@vt.edu

Ms. Jessica Zielske, Program Coordinator: jcoker@vt.edu

Program Website: <http://www.globalchange.vt.edu/igc/>

The Interfaces of Global Change (IGC) program is an innovative interdisciplinary graduate education program designed to address the multidimensional aspects of global change. Funded by the Virginia Tech Graduate School, this program is one of several Interdisciplinary Graduate Education Programs (IGEPs). These programs address a variety of complex societal issues requiring interdisciplinary teams of scholars. Participants (Ph.D. Fellows) typically enter the program at the beginning of their graduate studies and continue to participate

throughout their time at Virginia Tech. The Interfaces of Global Change program is closely aligned with the Global Change Center, which focuses on the social, economic, and environmental causes and consequences of global change. The goals of the IGC IGEP are to provide each PhD Fellow with a broad perspective on: The social, economic, and environmental causes and consequences of global change. The roles that science and scientists play informing public understanding, engaging with other stakeholders, designing sound environmental policy, and effective communication of science to diverse audiences. The purpose and practice of collaborative, team-based, interdisciplinary research. Professional development tools leading to career success. Ph.D. Fellows in the IGC IGEP will be part of a campus-wide network and community of scholars studying diverse facets of global change. During their tenure at Virginia Tech, they will have unique access to visiting scholars, workshops, and other professional development opportunities. After graduating, they will become part of our community of diverse alumni solving global challenges around the globe. Ph.D. Fellows enrolled in the IGC IGEP will receive training in the following four areas by integrating the training they receive in their home departments with the additional resources and opportunities provided by the IGC IGEP. Global change: The IGC emphasizes the social, economic, and environmental causes and consequences of global change. Students acquire understanding of these broad topics through a variety of mechanisms including: their dissertation research and supporting degree-related course work; the 3-credit "IGC breadth elective" required outside a student's disciplinary home; the annual IGC graduate student symposium; disciplinary and problem-based flash talks occurring in the seminar and capstone courses; exposure to experts hosted by the GCC for distinguished lectures, seminars, workshops, etc. Science in Society: The IGC emphasizes the roles of science and scientists in society and how our fellows can be more influential. The IGC seminars and capstone course emphasize this topic, along with invited speakers and professional development workshops. Example sessions from the seminar and capstone include advocacy versus honest broker; communicating science; science arbitration; joint fact finding; wicked problems and adaptive management, science policy; science advisory boards; government people and process; climate denial; decline of expertise; stakeholder analysis and transdisciplinarity. Collaborative Team Science: The IGC helps fellows effectively conduct multidisciplinary/ interdisciplinary research. The capstone course emphasizes this topic. Example sessions in the capstone include: team formation and function, conflict resolution, project management, differences of disciplinary, multidisciplinary, and interdisciplinary research; case studies from literature; case studies of global change faculty. Professional Development: The IGC helps fellows succeed as professionals. Topics covered in seminars and capstone include: career planning, CV writing, individual development plan, teaching versus research paths in academia, work-life balance, and psychological resilience. The Interfaces of Global Change program does not grant degrees. Students still receive their Ph.D. degree from their home department. The IGC provides students with a unique intellectual focus and additional training beyond the disciplinary expertise they develop in their home department. Our goal is for each student to gain depth in their specific scientific area of expertise while simultaneously gaining breadth in the multifaceted realm of global change and the science-policy interface. Our core faculty members represent a diversity of scientific and societal perspectives as well as a community of scholars spanning all stages of their academic career. We represent 21 departments and 8 colleges on campus, and one off-campus center, with strong inclusion of both the sciences and social sciences. Reaching across so many academic units is required to achieve our vision for interdisciplinary training. Colleges and Departments College of Agriculture and Life Sciences Agricultural and Applied Economics Biochemistry Entomology

School of Plant and Environmental Sciences College of Engineering
Biological Systems Engineering Civil and Environmental Engineering
Computer Science College of Liberal Arts and Human Sciences History
Philosophy College of Natural Resources and Environment Fish &
Wildlife Conservation Forest Resources and Environmental
Conservation Geography Sustainable Biomaterials Virginia Water
Resources Research Center College of Science Biological Sciences
Geosciences School of Neuroscience Statistics College of Architecture
and Urban Studies School of Public and International Affairs College of
Business Business Information Technology Hospitality and Tourism
Management College of Veterinary Medicine Population Health Sciences
Biomedical Sciences and Pathobiology

SPECIAL FACILITIES

207B Fralin Hall

The Interfaces of Global Change program is an interdisciplinary graduate program that draws faculty and graduate students from 8 colleges on campus. The main office is located in 207B Fralin Hall.

DEGREES OFFERED

IGEP Degree

Offered In (Blacksburg)

This is not a degree granting program

MATERIAL CULTURE & PUBLIC HUMANITIES

Matthew Gabriele, Chair

Professors: Brian Britt; Humberto Camilloni; Kevin Concannon; Arthur Ekirch;

Matthew Gabriele; Michael Saffle; Peter Wallenstein;

Associate Professors: Ananda Abeysekara; Aaron Ansell; Marilyn Casto; William

Green; Kathleen Jones; Brian Katen; Ann-Marie Knoblauch; Michelle Moseley

Christian; Anita Puckett; Paul Quigley; Emily Satterwhite; Peter Schmitthenner;

Rachel Scott; Daniel Thorp;

Assistant Professors: Melanie Kiechle; Zhange Ni; LaDale Winling;

Affiliated Faculty: Deborah Sim;

Graduate Contact: ansell78@vt.edu

Graduate Contact: mymc@vt.edu

Graduate Site: <http://www.rc.vt.edu/matcult/>

This 30-credit cross-disciplinary degree has two interrelated emphases, material culture and public humanities, and prepares students for a wide range of careers in museums, historical societies, archives, and community-building organizations. We take material culture to mean those tangible things--objects, landscapes, bodies-- that humans have shaped to their use; our studies examine these things from critical, theoretical, and historical perspectives, viewing them as expressions of

cultural logics and political struggles. We take the humanities-- including the disciplines of anthropology, art history, history, literature, and music-- to refer to the study of how people make meaning out of the world. Public humanities, for us, entails the project of partnering humanities scholars with those actors who produce knowledge and remake the world outside the university. The curriculum entails a minimum of 30-credits of graduate courses. We recommend that students enter the program in the fall semester. The deadline for applications for fall semester is February 15 to receive consideration for a funding (tuition and stipend) as a Graduate Assistant (GA) or Graduate Teaching Assistant (GTA). For more information about the MCPH MA Program, please visit our website: <https://www.mcph.liberalarts.vt.edu>, and feel free to contact the co-directors: Drs. Aaron Ansell (aansell@vt.edu) and Michelle Moseley (mymc@vt.edu).

SPECIAL FACILITIES

Students in the MA in Material Culture and Public Humanities can draw upon a variety of facilities, listed below, that will enrich their education.

Armory Gallery

Armory Gallery

Art + Architecture Library

Art + Architecture Library

Center for the Arts

Center for the Arts

Department of History

Department of History

Department of Religion and Culture

Department of Religion and Culture

School of Visual Arts

School of Visual Arts

Special Collections, University Libraries

Special Collections, University Libraries

DEGREES OFFERED

MA Degree

Offered In (Blacksburg)

TOEFL

Paper: (550.0)

iBT: (80.0)

Undergraduate B.S. or B.A. degree in a humanities or design discipline, with preference given to students with degrees in Art History, Anthropology, American Studies, History, Political Science, English, Communication, History of Design, Classics, Architecture, Landscape Architecture, Religion and Culture, Interior Design, or Industrial Design. Minimum of a 3.5 in-major undergraduate GPA, 3.0 overall undergraduate GPA. Official transcripts, 3 letters of recommendation, and all other documents required by the Graduate School. Applicants with work or internship experience in a related field will be given special consideration.

MOLECULAR AND CELLULAR BIOLOGY

Graduate Contact: silke@vt.edu

Graduate Contact: molsen1@vt.edu

Graduate Site: mcb.vt.edu

The MCB program at Virginia Tech is an interdisciplinary program in Molecular and Cellular Biology. Composed of faculty from six departments across the Virginia Tech campus and the Fralin Biomedical Research Institute, incoming students may choose research projects from four broad categories: Cell Signaling and Cancer, Inflammation and Immunity, Microbiology, and Neurobiology. Cell Signaling and Cancer Faculty members in Cell Signaling and Cancer study how cells sense and transduce signals, replicate, divide, differentiate, and adapt their functioning to the outside world. Techniques in this area include high-end microscopy, transcriptomics, proteomics, genetic tools, as well as structural and molecular biology. Inflammation and Immunity Research in Inflammation and Immunity covers the physiology and pathology of innate and adaptive immunity, and uses innovative technologies including lab-on-a-chip to study the interaction between immune cells and pathogens. Microbiology Research in the Microbiology track investigates how prokaryotes sense and respond to their environment. This includes symbiotic and pathogenic interactions, as well as mechanisms of antibiotic resistance and pathogen-induced cancer. Neurobiology Laboratories associated with the Neurobiology track investigate the genetic, molecular, and cellular mechanisms that underpin how the brain and body grow, sense the world around them, and ultimately create behavior. Current research is focused on cellular and molecular mechanisms related to drug addiction, mood disorders, neuroendocrinology, neuroimmunology, brain development, sexual differentiation, and language production. Faculty members use a wide range of cellular and organismal models, and employ innovative techniques including advanced genomics and proteomics, fluorescence microscopy, electrophysiology, biochemistry, molecular genetics and behavioral assays. Faculty members are committed to excellent, student-oriented mentoring in all aspects of research and professional development. Colleges and Departments College of Science Biological Sciences School of Neuroscience College of Veterinary Medicine Biomedical and Veterinary Sciences College of Agriculture and Life Sciences Biochemistry Human Nutrition, Foods, and Exercise Animal and Poultry Science For more information visit our website: mcb.vt.edu Contact information: mcb-program@vt.edu (540)-231-7394

SPECIAL FACILITIES

The Molecular and Cellular Biology Program at Virginia Tech is an interdisciplinary graduate program that draws faculty and graduate students from 3 colleges on campus. The main office is located in Life Sciences 1, Room 213.

DEGREES OFFERED

IGEP Degree

Offered In (Blacksburg)

This is not a degree-granting program. Students receive their degree from the home department of their research supervisors. The department requirements apply.

BIOLOGICAL TRANSPORT

Professors: Daniela Cimini; Rafael Davalos; Raffaella De Vita; Linsey Marr;

Shane Ross; David Schmale; John Socha; Mark Stremler;

Associate Professors: Maria Lazar; Stephen Melville; Eva Schmelz;

Assistant Professors: Jonathan Boreyko; Jing Chen; Caroline Jones; Shima Shahab; Clement Vinauger Tella;

Research Assistant Professors: Chloe Lahondere;

Program Administrator: sallys@vt.edu

Biological Transport Program: <http://www.biotrans.fralin.vt.edu/>

The Biological Transport (BIOTRANS) program provides a framework for interdisciplinary education and research that trains future leaders of academic and industrial research to think, collaborate, and contribute at the intersection of the biological and engineering sciences. This program develops participants who are experts in a core discipline of engineering or biology and who are also proficient in the alternate discipline, with understanding and appreciation of its methods, culture, and perspectives. BIOTRANS trainees can receive 12 months of financial support from the program while working toward a graduate degree in one of the departments listed below. To receive full consideration for financial support in the following academic year, applications should be submitted by January 15. For more information please visit the BIOTRANS website or contact Sally Shrader, Program Administrator, via email at sallys@vt.edu Colleges, Programs, & Faculty (*Executive Committee members): College of Engineering Aerospace and Ocean Engineering - Shane Ross Civil & Environmental Engineering – Linsey Marr Electrical & Computer Engineering Biomedical Engineering & Mechanics – Rafael Davalos, Raffaella De Vita, *Jake Socha, Mark Stremler Mechanical Engineering - Jonathan Boreyko, Shima Shahab College of Science Biological Sciences – Jing Chen, *Daniela Cimini, Caroline Jones, Iuliana Lazar, Steve Melville College of Agricultural & Life Sciences Biochemistry - Chloe Lahondere, Clement Vinauger Human Nutrition, Foods, and Exercise – Eva Schmelz School of Plant and Environmental Sciences Plant Pathology, Physiology & Weed Science – David Schmale

SPECIAL FACILITIES

Program participants have access to the office and laboratory facilities of their advising faculty; see the faculty list under Program Overview.

DEGREES OFFERED

IGEP Degree

Offered In (Blacksburg)

TOEFL

Paper: (550.0)

iBT: (80.0)

GRE

Biological Transport (BIOTRANS) previously known as Multi-Scale Transport in Environmental and Physiological Systems participants earn a degree from one of the participating degree-granting programs; see the list of programs under Program Overview and visit the relevant Graduate Catalog entry for your program of interest.

NEUROSCIENCE

Michael Fox, Chair

General Contact: gradneuro@vt.edu

Graduate Contact: molsen1@vt.edu

Graduate Site: <https://neuroscience.vt.edu/graduate.html>

Note that the final deadline for application submission is February 1. Priority is given to applications submitted before December 1. Our Ph.D. students will apply the fundamentals of brain functioning in states of health and disease to new neuroscience discovery. We aim to provide students with a deep understanding of the structure and function of the brain and nervous system, the brain in healthy and diseased states across the lifespan, and the most relevant neurotechnology approaches and tools needed to investigate the brain and nervous system. Our students will learn how to conduct neuroscience research, how that research applies to healthy brain development and functioning, and how these processes go awry in neurological disorders. Our graduates will be prepared for employment in academia, industry and government agencies, as well as business and research settings that seek to understand, translate, implement, and communicate scientific principles in neuroscience.

SPECIAL FACILITIES

Please visit our website for information: Neuroscience PhD Website. You can also email: neurograd@vt.edu

Neuroscience PhD Facilities

Facilities for this program can be found in the following locations: Sandy Hall Life Sciences 1, Ictas 2, Stegar Hall Corporate Research Center

DEGREES OFFERED

PhD Degree

Offered In (Blacksburg)

Neuroscience PhD requirements: 96 Total Credit Hour minimum for additional details visit our website Neuroscience PhD VT. Neuroscience core (18 credits) NEUR 5004: Principles in Neuroscience (3 credits) NEUR 5014: Fundamentals of Cellular Neuroscience (3 credits) NEUR 5024: Neuroanatomy and Systems Neuroscience (3 credits) NEUR 5074: Current Topics in Neuroscience (1 credit x 4 = 4 credits) STAT 5615: Statistics in Research (3 credits) Laboratory Rotations: 1. NEUR 5374: Research Experience in Neuroscience (2 credits) Restricted Electives (6-12 credits) Students will select a minimum of 6 credit hours and a maximum of 12 credit hours from a prescribed list of courses. Selected coursework must be approved by the student's advisor. NEUR 5034G: Advanced Diseases of the Nervous System (3 credits) NEUR 5054: Developmental Neuroscience (3 credits)

NEUR 5064: Cognitive and Behavioral Neuroscience (3 credits) NEUR 5314G: Advanced Genetics of Neuroscience (3 credits) NEUR 5364G: Advanced Neuroscience of Language and Comm Dis (3 credits) NEUR 5514G: Advanced Neuroimmunology (3 credits) NEUR 5814G: Advanced Nutritional Neuroscience (3 credits) NEUR 5914: Neuroscience of Drug Development (3 credits) NEUR 6014: Glial Biology (3 credits) Free Electives (6-12 credits) Students will select a minimum of 6 credit hours and a maximum of 12 credit hours of graduate coursework at the 5000 level or higher. All courses must be approved by the student's advisor as part of the Plan of Study. Courses can come from any graduate course offerings at the institution. Independent Research: Independent Research is conducted with a thesis advisor throughout the duration of the program. A thesis advisor is selected at the end of the first semester in the program following the two laboratory rotations.

GRADUATE COURSES (NEUR)

NEUR 5004:

Principles of Neuroscience

Structure of the nervous system, membrane properties, and electrical properties of neuronal cells. Neurotransmitter systems, synapse structure and function. Overview of neural development, sensory and motor systems, memory, emotion, decision making, and behavior.

Theories to study neurological structures and functions. Assessment of scientific literature. Pre: Graduate Standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

NEUR 5014:

Fundamentals of Cellular Neuroscience

Fundamentals of molecular signaling in the nervous system. Underlying neuronal signaling that includes the channels, transporters and pumps.

Methods to study synaptic plasticity, structure and function of nervous system cells. Current understanding of the cellular and molecular basis of nervous system disorders. Assessment of scientific literature. Pre:

Graduate Standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

NEUR 5024:

Neuroanatomy and Systems Neuroscience

Anatomy and function of the human central and peripheral nervous system, including gross and microscopic structure of major neural circuits that govern motor and sensory systems, autonomic function, memory, emotion, motivation and attention. Diseases and disorders associated with brain region malfunction. Pre: Graduate Standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

NEUR 5034G:

Advanced Diseases of the Nervous System

Common brain and Central Nervous System (CNS) disorders ranging from trauma to autism. Genetic, molecules and cellular changes in disease. Therapeutic implications and development of novel drugs. Challenges in drug discovery and implementation of personalized medicine. Ethical issues regarding genetic findings. Pre: Graduate Standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

NEUR 5054:

Developmental Neuroscience

Molecular and cellular processes underlying neural circuit formation, including neural induction, cell differentiation, cell fate determination, axon guidance, neuronal migration, synapse formation, sex differentiation, the role of neurotrophic factors, and cell death in vertebrate and invertebrate animal models. Gene regulation during critical periods of neural development that define neurogenesis and gliogenesis. Clinical problems in developmental neuroscience. Writing. Pre: Graduate Standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

NEUR 5064:

Cognitive & Behavioral Neuroscience

Concepts and methods in cognitive neuroscience. Neural bases of various mental functions including sensation, memory, attention, motivation and reward, emotion, decision making, sleep, language and social cognition. Treatment of neurological and mental disorders. Pre: Graduate Standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

NEUR 5074:

Current Topics in Neuroscience

Discussion of emergent topics, theory and techniques in contemporary neuroscience research. Current research literature review of select topic. Scientific communication, ethics, and research integrity. May be repeated with different topics for a maximum of 4 credits. Pre: Graduate Standing.

Credit Hour(s): 1

Lecture Hour(s): 1

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

NEUR 5314G:

Advanced Genetics in Neuroscience

Concepts of classical, modern genetics and epigenetics as they relate to neuroscience. Practical applications including genome-wide association (GWAS), next-generation sequencing, epigenetics, genome editing and screening methods. Use of model organisms in neurogenetic disorders research. Relationship of genetics and its influences on theoretical and practical issues in neurological and neurodevelopmental disorders. Personalized medicine in neurodevelopmental and neurogenetic disorders. Pre: Graduate Standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

NEUR 5364G:

Advanced Neuroscience of Language & Communication Disorders

Concepts of language as distinctive human behavior and central to social life. Neural underpinnings of humans ability to speak and

understand language. Neurologic processing of language comprehension and production in healthy and language-impaired individuals. Auditory and visual word recognition, reading, understanding speech, representation of word meaning, language production, and bilingualism. Neuroethology of communication and neurological disorders of communication: dyslexia, stuttering, and aphasia. Theoretical issues in language processing and converging evidence from different techniques and animal models addressing these issues.

Pre: Graduate Standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

NEUR 5374:

Research Experience in Neuroscience

Hands-on research experience in neuroscience. Hypothesis testing, experimental design, research methods, accurate record keeping, and data analysis. Scientific literature evaluation, problem solving, and scientific communication skills. May be repeated once for a maximum of four credits. Co: 5004 or 5014 or 5024.

Credit Hour(s): 2

Lecture Hour(s):

Instruction Type(s): Lab, VB

Instruction Type(s): Lab, VB

Prerequisite(s):

Corequisite(s):

NEUR 5514G:

Advanced Neuroimmunology

Immune system and assorted roles in psychiatric and neurological disorders. Details of cell type, functions and signaling of the peripheral and central immune system, and sympathetic nervous system. Cross-talk between the brain and immune system across the blood brain barrier and circumventricular organs. Treatment options for autoimmune diseases and psychopathy. Pre: Graduate Standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

NEUR 5814G:

Advanced Nutritional Neuroscience

Concepts in nutritional aspects of neuroscience. Energy metabolism in central nervous system and brain regulating ingestive behavior.

Communication with peripheral organs, regulation of whole body energy homeostasis, brain physiology and pathology on molecular and cellular level. Role of appetite neurocircuitry in formulation of practical solutions to societal problems such as nutrition, eating disorders, and obesity. Pre: Graduate Standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

NEUR 5844:

Computational Neuroscience

Concepts in modeling theoretical neuroscience. Study of information processing in the central nervous system integrating neuroscience, mathematics, computer science, and engineering. Basic information theory. Neural coding schemes using MATLAB. Advanced signal processing techniques for the analysis of neural data, neural modeling, and model architectures. Pre: Graduate Standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

NEUR 5984:

Special Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

NEUR 5994:

Research and Thesis

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research

Instruction Type(s): Research

574 Prerequisite(s):

Corequisite(s):

NEUR 6014:

Glial Biology

Cell biology and physiology of glial cells during synaptogenesis, myelination, blood-brain barrier formation and maintenance. Interactions of glial cells with neurons, the vasculature and immune system. Role of glial cells in the clearance of waste products and in the development and progression of neurological diseases. Animal models in glial biology research.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): NEUR 5014 OR TBMH 5014

Corequisite(s):

NEUR 6034:

Diseases of the Nervous System

Common brain and Central Nervous System (CNS) disorders including epilepsy, acute CNS trauma, neurodegenerative diseases, neurodevelopmental disorders, and certain mental illnesses. Genetic, molecular, and cellular changes in disease. Therapeutic implications, current limitations, and development of novel drugs. Use of animals to model human disease. Challenges in drug discovery and implementation of personalized medicine. Ethical issues regarding genetic findings.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): NEUR 5004 OR TBMH 5014

Corequisite(s):

NEUR 6984:

Special Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

NEUR 7994:

Research and Dissertation

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Research, Online Lecture

Instruction Type(s): Lecture, Research, Online Lecture

Prerequisite(s):

Corequisite(s):

NUCLEAR ENGINEERING

Azim Eskandarian, Head

Professors: Alireza Haghighat; Jinsuo Zhang;

Associate Professors: Celine Hin; Yang Liu;

Assistant Professors: Juliana Pacheco Duarte;

Affiliated Faculty: Xianming Bai; Diana Farkas; Roop Mahajan; Sonja Schmid; Danesh Tafti; James Turso;

Associate Professor of Practice: Mark Pierson;

Graduate Contact: haghighat@vt.edu

General Contact: negrad@vt.edu

General Contact: arjones@vt.edu

ME Department: <http://www.me.vt.edu>

Bursar's Office - Tuition: <http://www.bursar.vt.edu/>

University Scholarships and Financial Aid: <http://www.finaid.vt.edu/>

Timetable of Classes:

https://banweb.banner.vt.edu/ssb/prod/HZSKVTSC.P_DisRequest

Fellowships and Scholarships: <https://nuclear.ncr.vt.edu/admission/funding-opportunities>

Research: <https://nuclear.ncr.vt.edu/research>

Student Medical Insurance:

<http://risk.controller.vt.edu/studentmedicalinsurance.html>

Dates & Deadlines: <http://registrar.vt.edu/dates-deadlines-accordion.html>

New Student Checklist: <http://graduateschool.vt.edu/admissions/getting-started-as-a-student/new-student-checklist.html>

College of Engineering: <http://www.eng.vt.edu/>

Historical Time Table of Classes:

https://banweb.banner.vt.edu/ssb/prod/HZSKVTSC.P_DisHistorical

Office of Student Veterans Services: <https://www.veterans.vt.edu/>

Immigration Services: <http://graduateschool.vt.edu/student-life/immigration-services.html>

Nuclear Engineering Prog.: <https://nuclear.ncr.vt.edu>

Funding opportunities: <https://graduateschool.vt.edu/funding.html>

Research Groups: <http://www.me.vt.edu/nuclear-engineering-program/research-areas-2/>

In response to the growing demand from nuclear industry in Virginia, Virginia Tech restarted its nuclear engineering program (NEP) within the Mechanical Engineering Department and offers graduate degrees (Ph.D,

MS & MEng) in Nuclear Engineering. Additionally, NEP offers an accelerated MEng in Nuclear Engineering to the US Naval Academy midshipmen., a Graduate Certificate in Nuclear Engineering, and a Graduate Certificate in Nuclear Science Technology and Policy (NSTEP). The NSTEP Graduate Certificate is a joint program between NEP and the STS Department and the School Public and International Affairs (SPIA). Recently, NEP has established an Undergraduate Minor in Nuclear Engineering. The NEP faculty are engaged in different applications of nuclear science and engineering including power, security, medicine, and policy. To accomplish its research and educational mission, NEP has established collaborations with other VT programs such as Mechanical Engineering, Materials Science and Engineering, Physics, Computer Science and Visualization, School of Public and International Affairs, and Science, Technology and Society. Several faculty from these programs are working with the NEP faculty on different educational and research activities. For further information about NEP, visit the program website.

SPECIAL FACILITIES

The reintroduction of the Nuclear Engineering degree program has led to facilities available across the Commonwealth of Virginia, including Falls Church and Blacksburg. Interdisciplinary research projects cross several departmental boundaries to provide richer opportunities for graduate students. For further information on nuclear facilities, visit the facilities' webpage

Access to the US Naval Academy nuclear facilities

Under a partnership between the US Naval Academy (USNA) and Virginia Tech, with support from the USNA faculty and staff, the VT nuclear engineering faculty and students can conduct experiments in support of their research activities at the USNA, Annapolis, MD.

Goodwin Hall & Northern Virginia Center, Falls Church

The Goodwin Hall and the Northern Virginia Center (Falls Church) houses the Nuclear Engineering offices.

Heat Transfer and Safety Laboratory

Director Juliana Pacheco Duarte Heat Transfer and Safety Laboratory (HEATS) conducts experimental and computational investigation of two-phase flow phenomena such as post-critical heat flux heat transfer, boiling, and condensation. Our research efforts focus on the thermal-hydraulics and safety analysis of advanced nuclear systems to improve safety, security, and economic features of the next generation of nuclear reactors. We work with verification and validation of subchannel and system thermal-hydraulics codes and inverse heat transfer problems.

Multi-physics for Advanced Reactor Simulation (MARS) Center - Greater Washington DC

Director: Prof. Alireza Haghighat, Nuclear Engineering
Program Objectives: Development of novel methodologies and computer codes for design and analysis of advanced (safer, sustainable, and more efficient) nuclear reactors, such as the Molten Salt Reactor (MSR) designs. The Center has attracted national and international collaborations on preparation of proposals, new funding, publications and invited talks. It is envisioned that MARS will enable Virginia Tech to become an internationally recognized hub for development of

multiphysics modeling and simulation for Advanced Nuclear Reactors. VT Participating Programs: Nuclear Engineering (Celine Hin, Yang Liu, Jinsuo Zhang), Material Science and Engineering (Celine Hin), Mechanical Engineering, Physics (Jonathan Link, Patrick Huber and Bruce Vogelaar), and VT Visualization Center (Nicholas Polys) National and International partners: U.S. Universities: Georgia Tech (Bojan Petrovic, Farzad Rahnema, and DingKang Zhang); North Carolina State University (Maria Avramova, Kostadin Ivanov). U.S. Industry: Southern Company Services (Nick Smith); with letters of support from TerraPower, Transatomic Power, Elysium Industries, Flibe Energy. U.S. National Laboratories: Oak Ridge National Laboratories (Kevin Robb, Ben Betzler) International Organizations: Jozef Stefan Institute (Luka Snoj), Politecnico di Milano, Italy (Antonio Cammi), Politecnico di Torino, Italy (Piero Ravetto, Sandra Dulla, Co-PIs), and University of Ljubljana (Iztok Tiselj)

Multiphase Flow and Thermal-hydraulics Laboratory (MFTL)

Director: Prof. Yang Liu The laboratory performs experimental and computational studies on various multiphase flow and reactor thermal-hydraulics topics. In the first area, we study the full spectrum of two-phase flow regimes that are of practical interest, ranging from bubble nucleation to film and droplet dynamics. Research activities include advanced instrumentation development, experimental studies, and model development for both 1-D system codes and 3-D CFD codes. In the area of reactor thermal-hydraulics, the focus is on reactor safety related issues. Specific topics include air entrainment in the emergency core cooling system, flow structure development in rod bundles, flow induced vibration on piping elements, passive safety systems, and spent fuel pool safety. MFTL has several test loops for two-phase flow experiment and instrumentation development. These test loops are equipped with high-precision instruments including magnetic flow meters, air mass flow meters, and differential pressure transducers. An existing high-speed imaging system consists of multiple (up to five) high-speed cameras, with an attainable frame rate up to 500,000 fps and resolution up to 6016x1024 pixels. A fast X-ray line-detector system can provide X-ray imaging at spatial resolution of 100 micrometer and a frame rate exceeding 1000 Hz. MFTL also has the capability to develop in-house instrumentation systems, such as multi-sensor conductivity probes, impedance void meters, and film thickness sensors. The dedicated computing resources include a 64-core AMD Opteron workstation and several multi-core Intel Xeon based workstations. The lab has access to Virginia Tech's high-performance computing systems, which houses more than five high performance clusters and necessary software packages including ANSYS CFX, ANSYS FLUENT and OpenFOAM, to perform single- and multi-phase CFD simulations.

Nuclear Materials and Fuel Cycle Center

Director: Prof. Jinsuo Zhang, The Nuclear Materials and Fuel Cycle Center (NMFC) focuses on two research topics: material degradation in

a nuclear reactor and electrochemical separation for nuclear applications. Degradation of structural materials including fuel cladding has been recognized as one of the key factors that affect the performance of a nuclear reactor, especially for Gen.IV advanced reactors. The material degradation can be due to the corrosive property of a nuclear coolant such as liquid metal, molten salt and high temperature water or the chemical reactions between different materials such as fuel cladding chemical interactions (FCCI). Electrochemical separation has been found to be an effective method to separate nuclear materials from spent nuclear fuels. The method is also one of the candidate methods for molten salt coolant purification. Specifically, the center focuses on studies of advanced used nuclear fuel reprocessing, material compatibility and materials corrosion in advanced and current nuclear reactors. Ongoing research activities are: 1) Nuclear Materials compatibility (materials corrosion/degradation), 2) Nuclear Fuel Cycle Technology; 3) Electrochemical Separation; 4) Nuclear Safeguards and nonproliferation; and 5) Advanced Coolant Materials (molten salt, liquid metal). The Center benefits from two recently established facilities: A Molten Salt Chemistry Loop for determination of chemical properties of molten salt fuel under high temperature.. Two specialized high-temperature water loops for investigation of materials performance in high temperature environments

Radiation Measurement and Simulation Laboratory (RMSL)

Director: Assoc. Prof. of Practice Mark Pierson The laboratory supports research activities in radiation detection and materials, radiation dosimetry, light-weight radiation shielding materials, radiation detection arrays, nuclear safeguards, design of passive and active interrogation systems, and benchmarking of particle transport codes. In addition, it provides modeling and simulation of the results. Finally, it provides radiation literacy through experiments conducted by students in the various nuclear engineering courses. Equipment included in the lab: Reverse electrode Germanium detector, 60% efficiency with hybrid cryostat Digital spectrum analyzer NaI and LaBr scintillation detectors Various radiation detection instruments and probes Lead-shielded counting systems 32 processor computational cluster with large panel displays for visualization

Virginia Tech's Advanced Research Computing

Virginia Tech's Advanced Research Computing: Advanced Research Computing (ARC) at Virginia Tech is an innovative and interdisciplinary environment advancing computational science, engineering and technology. Its mission is to:-Provide computing and visualization resources, support, and leadership to advance computational research at Virginia Tech.-Provide partnerships and support for joint faculty appointments in academic departments, building areas of excellence in computational science and engineering across disciplines, and providing opportunities for new innovation in scientific computing.-Offer educational programs and training on scientific computing, encouraging

the development of knowledge and skills in computational tools and techniques for undergraduate, graduate and research faculty and staff.- Offer programs to stimulate and expand interdisciplinary and computational driven research activity at VT, including visiting researcher, travel, distinguished postdoctoral fellow and graduate student programs that provide new sources of support for collaboration, research, and development.-Affiliate with business, industry, and government to help drive economic development growth in Virginia by building connections between research and applications for emerging tools and techniques in computational science and engineering.- Collaborate with other computational science and engineering driven research centers in advancing knowledge and leading the evolution of scientific computing tools, techniques, and facilities that accelerate scientific discovery.

DEGREES OFFERED

MS Degree

Offered In (Blacksburg, National Capital Region)

TOEFL

Paper: (620.0)

iBT: (105.0)

TOEFL Computer Based

Computer Based: CBT (260.0)

GRE

General: Verbal (150.0), Quantitative (165.0), Analytical (4.5)

Please contact negrad@vt.edu for specific location information. Acceptance into the VT Nuclear Engineering graduate program is based on the overall application package. Admission does not guarantee financial assistance. In general, the minimum target requirements are to the left. The application materials required can be accessed from the application instructions web page. Master of Science (MS) Degree Requirements Earning an MS degree requires completing a 30 credit hour program subject to the following requirements. Except as indicated, courses must be taken for a grade, not Pass/Fail. MS students must submit a Plan of Study before completing the first semester registered as a MS student. No grade below B- is allowed for any core course. 1. Master of Science Courses: A minimum of 21 graded credit-hours of courses must be taken including the following: a. Core Courses (15 graded credit-hours) which include four required courses and one mathematics/statistics course: 12 credit-hours of required courses: (1) NSEG 5124 Nuclear Reactor Analysis (2) NSEG 5204 Nuclear Fuel Cycle (3) NSEG 5604 Radiation Detection and Shielding (4) either NSEG 5424 Reactor Thermal Hydraulics or MSE 5384G Advanced Nuclear Materials A minimum of 3 graded credit-hours of a mathematics or statistics course from an approved list of courses. b. Elective Courses: Six credit-hours of any science, engineering or mathematics 5000-level, or higher, courses as approved by the Advisory Committee are required. However, if only six credit-hours of NSEG 5994 are applied toward the degree instead of nine credit-hours (see Research Requirements below), the student must take an additional 3 credits of any science, engineering or mathematics 5000-level, or higher course, as approved by their Advisor, to satisfy the requirement for a

total of 30 credit hours for the M.S. degree. The graded course work may include 5984/6984 Special Study. However, a student cannot exceed a maximum of 6 credit hours of 5974, 5984, and 6984. 2. Master of Science Research Requirement: A minimum of 6 credit-hours of NSEG 5994 Research and Thesis, not to exceed 9 credit-hours, must be completed. Additional Requirements: All students must satisfactorily pass an oral final examination, write and successfully defend a thesis. Seminar Program: All students must participate in the nuclear engineering program seminar series. Ethics: All graduate students must meet the Graduate School's Ethics requirement by completing GRAD 5014 Academic Integrity & Plagiarism within the first two semesters. Course work From Another Institution (MS): Per the Graduate School, not more than 50% of required graded course work from another institution may be transferred. All transferred course credits must have the grade of "B" or higher and must have been earned while enrolled as a graduate student. Transfer work is evaluated/approved when the Plan of Study is submitted. All transfer credits must be accompanied by transcripts which verify grades. Course descriptions are also required. Transfer courses on the Plan of Study must be approved by the student's Advisory Committee. It is anticipated that students complete the MS program in two years following undergraduate studies in a nuclear related field, or with a minor in a nuclear related field. If a student already has a B.S. in Nuclear Engineering, they are expected to complete the MS program in less time, perhaps in as few as three semesters. No courses below the 5000 level will be accepted for graduate credit.

MEng Degree

Offered In (Blacksburg, National Capital Region)

TOEFL

Paper: (620.0)

iBT: (105.0)

GRE

General: Verbal (150.0), Quantitative (165.0), Analytical (4.5)

TOEFL Computer Based Test

CBT Score: CBT Score (260.0)

Please contact negrad@vt.edu for specific location information. Acceptance into the VT Nuclear Engineering graduate program is based on the overall application package. Admission does not guarantee financial assistance. In general, the minimum target requirements are to the left. The application materials required can be accessed from the application instructions web page. Master of Engineering (MEng) Degree Requirements Earning a MEng degree requires completing a 30 credit hour program subject to the following requirements. Except as indicated, courses must be taken for a grade, not Pass/Fail. MEng students must submit a Plan of Study before completing the first semester registered as a MEng student. No grade below B- is allowed for any core course. 1. Master of Engineering Courses: A minimum of 24 graded credit-hours of courses must be taken including the following: a. Core Courses (15 graded credit-hours) which include four required courses and one mathematics/statistics course: 12 credit-hours of required courses: (1) NSEG 5124 Nuclear Reactor Analysis (2) NSEG 5204 Nuclear Fuel Cycle (3) NSEG 5604 Radiation Detection and Shielding (4) either NSEG 5424 Reactor Thermal Hydraulics or MSE 5384G Advanced Nuclear Materials A minimum of 3 graded credit-hours of a mathematics or statistics course from an approved list of courses. b. Additional NSEG Course: An additional 3 credit-hours of a graded NSEG 5000-level, or higher, course is required. c. Elective Courses: Six credit-hours of any science, engineering or mathematics 5000-level, or higher, course as approved by the Advisory Committee are required. However, if

only three credit-hours of NSEG 5904 are applied toward the degree instead of six credit-hours (see Project Requirements below), the student must take an additional 3 credits of any science, engineering or mathematics 5000-level, or higher course, as approved by the Advisory Committee, to satisfy the requirement for a total of 30 credit hours for the MEng degree. The graded course work may include 5984/6984 Special Study. However, a student cannot exceed a maximum of 6 credit hours of 5974, 5984, and 6984. 2. Master of Engineering Project Requirement: A minimum of 3 credit-hours of NSEG 5904 Project and Report, not to exceed 6 credit hours, must be completed. Additional Requirements: All students must satisfactorily pass an oral final examination, write and successfully defend a Project & Report. Seminar Program: All students must participate in the nuclear engineering program seminar series. Ethics: All graduate students must meet the Graduate School's Ethics requirement by completing GRAD 5014 Academic Integrity & Plagiarism within the first two semesters. Course work From Another Institution: Per the Graduate School, not more than 50% of required graded course work from another institution may be transferred. All transferred course credits must have the grade of "B" or higher and must have been earned while enrolled as a graduate student. Transfer work is evaluated/approved when the Plan of Study is submitted. All transfer credits must be accompanied by transcripts which verify grades. Course descriptions are also required. Transfer courses on the Plan of Study must be approved by the student's Advisory Committee. It is anticipated that students complete the MEng program in two years following undergraduate studies in a nuclear related field, or with a minor in a nuclear related field. If a student already has a B.S. in Nuclear Engineering, they are expected to complete the MEng program in less time, perhaps in as few as three semesters. No courses below the 5000 level will be accepted for graduate credit.

PhD Degree

Offered In (Blacksburg, National Capital Region)

TOEFL

Paper: (620.0)

iBT: (105.0)

GRE

General: Verbal (150.0), Quantitative (165.0), Analytical (4.5)

Computer Based TOEFL

CBT Score: CBT Score (260.0)

Please contact negrad@vt.edu for specific location information. Acceptance into the VT Nuclear Engineering graduate program is based on the overall application package. Admission does not guarantee financial assistance. In general, the minimum target requirements are to the left. The application materials required can be accessed from the application instructions web page. A Ph.D student has a deeper knowledge of the nuclear engineering subject matter than a Master's student and, is expected to carry out a comprehensive research project. Earning a Ph.D. requires the completion of a 90 credit hour program (including the courses taken for a Master's degree) subject to the following requirements. Except as indicated, courses must be taken for a grade, not Pass/ Fail. No grade below B- is allowed for any core course. Doctor of Philosophy (Ph.D) Degree Requirements The 90 credit hours are made up of (1) 30 graded credit hours of coursework consisting of six core courses and four additional courses in the categories of NSEG 6000 level courses, Breadth or Elective courses, (2) 30 credit hours of research, and (3) 30 credit hours of enhancement courses which may consist of either research credits or graduate level courses taken from any unit of the University. 1. Doctor of Philosophy

Courses: A minimum of 30 graded credit hours of courses must be taken including the following:

- Core Courses (18 graded credit hours) which include four required courses and two mathematics/statistics courses: 12 credit hours of required courses: (1) NSEG 5124 Nuclear Reactor Analysis (2) NSEG 5204 Nuclear Fuel Cycle (3) NSEG 5604 Radiation Detection and Shielding (4) either NSEG 5424 Reactor Thermal Hydraulics or MSE 5384G Advanced Nuclear Materials. A minimum of 6 graded credit hours of a mathematics or statistics courses from an approved list of courses.
- 6000-level NSEG Courses: Any two NSEG 6000 level courses as approved by the Advisory Committee.
- Breadth Requirement: An additional 3 credit hour NSEG 5000 level, or higher, graded course. This course should provide some breadth by being in an area outside the student's specialization as determined by the student's Advisory Committee.
- Elective Course: Three credit hours of any science, engineering or mathematics 5000 level, or higher, course as approved by the Advisory Committee is required. The graded course work may include 5984/6984 Special Study. However, a student cannot exceed a maximum of 12 credit hours of 5974, 5984, and 6984.

2. Doctor of Philosophy Research Requirement: A minimum of 30 credit hours of NSEG 7994 Research & Dissertation must be completed successfully.

3. Doctor of Philosophy Enhancement Requirement: A minimum of 30 additional credit hours consisting of a combination of either graduate coursework (5000 level or higher) from any unit of the University and/or research and dissertation credits (NSEG 7994), as approved by the student's Advisory Committee. These credits are tailored for the specific research topic and background of the student. Additional in-depth courses related to the student's research area, if applicable, would be included under this requirement. Moreover, students who plan to enter academia after completion of their Ph.D are encouraged to take electives such as GRAD 5104 Preparing the Future Professoriate and ENGE 5014 Foundations of Engineering Education. Those planning to enter industry are encouraged to take electives such as GRAD 5314 Future Industrial Professional in Science and Engineering. Obtaining a Graduate Certificate in the Future Professoriate or other areas are also encouraged. These electives will also satisfy part of the 30 credit hours enhancement requirement.

Additional Requirements: All students must satisfactorily pass the qualifying, preliminary and oral final examinations, write and successfully defend a dissertation, and complete a residency experience through full-time enrollment on the Virginia Tech Blacksburg campus or National Capital Region campus for two consecutive semesters.

Seminar Program: All students must participate in the nuclear engineering program seminar series.

Ethics: All graduate students must meet the Graduate School's Ethics requirement by completing GRAD 5014 Academic Integrity & Plagiarism within the first two semesters.

Course work From Another Institution: Per the Graduate School, not more than 50% of required graded course work from another institution may be transferred. All transferred course credits must have the grade of "B" or higher and must have been earned while enrolled as a graduate student. Transfer work is evaluated/approved when the Plan of Study is submitted. All transfer credits must be accompanied by transcripts which verify grades. Course descriptions are also required. Transfer courses on the Plan of Study must be approved by the student's Advisory Committee. No courses below the 5000 level will be accepted for graduate credit toward the Doctor of Philosophy in Nuclear Engineering.

MEng Degree

Offered In (Blacksburg, National Capital Region)

An accelerated graduate program for students from the US Naval Academy (USNA) who receive a BS degree in Nuclear Engineering, or

Naval Officers may enroll in the Masters of Engineering (MEng) degree in the Nuclear Engineering Program at Virginia Tech. The requirements for this program are listed below:

- Undergraduate students from USNA must be accepted into the program prior to the spring semester of the academic year.
- Students qualifying for the program must be in the last 12 months of their undergraduate degree and are expected to complete their degree by the end of the spring semester of the academic year. Once completion of the undergraduate degree has been verified, students accepted into this accelerated program will be classified as regular graduate students.
- Students will take 10 credits of graded coursework during the spring semester that may be used towards meeting the MEng degree requirement.
- Students will not double count any courses for the undergraduate USNA and graduate VT degrees.
- Students admitted in the program must have a GPA of 3.0 or better.
- Students must maintain a GPA of 3.0 or better during their first semester (spring semester of the academic year) to be accepted as regular graduate students upon their graduation from USNA.

Courses must not be taken pass/fail if a graded option is available.

GRADUATE COURSES (NSEG)

NSEG 5114:

Nuclear Eng Fundamentals

A foundation course in nuclear engineering. Neutron physics, reactor theory and kinetics, basic reactor design and operation, and overall power plant operation. Pre-requisite: Graduate Standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

NSEG 5124:

Nuclear Reactor Analysis

Nuclear reactions and fission process. The fission chain reaction. Neutron diffusion and moderation. One-speed diffusion model of a nuclear reactor. Neutron slowing and multigroup diffusion theory. Nuclear reactor kinetics. Introduction to reactor core physics design.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): NSEG 5114

Corequisite(s):

NSEG 5134:

Monte Carlo Particle Transport

Basic particle transport concepts. Random processes, random number generation techniques, fundamental formulation of Monte Carlo,

sampling procedures, and fundamentals of probability and statistics. Monte Carlo algorithms for particle transport, non-analog Monte Carlo method, formulations for different variance reduction techniques, and tallying procedures. Methodologies for parallelization and vectorization of the Monte Carlo methods, and examples of the Monte Carlo method for simulation of various real-life applications. Graduate standing required

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

NSEG 5204:

Nuclear Fuel Cycle

Uranium nuclear fuel cycle: mining, conversion, enrichment, fuel manufacturing, in-core fuel management and refueling, spent fuel storage, reprocessing/recycling and final disposition as waste in a geologic repository. Introduction to nuclear safeguards and nonproliferation as applied to each step of the cycle. Pre-requisite:

Graduate Standing required

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

NSEG 5214:

Nuclear Plant Systems & Ops

Pressurized and boiling water reactors, detailed system functions and operation, reactor plant startup and shutdown procedures, reactor trip and casualty procedures, reactor transient response analysis, reactor plant licensing, ethics and integrity in the nuclear industry.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): NSEG 5114

Corequisite(s):

NSEG 5284 (STS 5284) (SPIA 5284):

Nuclear Nonproliferation, Safeguards, and Security

Technical essentials, policy analysis, theoretical perspectives of nuclear energy and nuclear nonproliferation. Fundamentals of the nuclear fuel cycle, management of international safeguards, threat of nuclear terrorism, and challenges for global nuclear industry. Pre: Graduate

standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

NSEG 5424:

Reactor Thermal Hydraulics

Fundamental processes of heat generation and transport in nuclear reactors. Heat generation by fission and radiation interactions; spatial distribution of heat generation; heat transport by conduction and convection. Effects of boiling and critical heat flux. Fundamentals of reactor thermal and hydraulic design.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): NSEG 5114

Corequisite(s):

NSEG 5504 (MSE 5504):

Radiation Effects on Metals and Alloys

Radiation effects on metals and alloys. Interaction between particles and atoms, radiation damage, displacement of atoms, diffusion of point defects, radiation-induced segregation, phase instability, transmutation products, irradiated material mechanical properties. Pre: Graduate Standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

NSEG 5514:

Structural Materials Degradation in Nuclear Power Systems

High temperature failure mechanisms and corrosion in applications of nuclear engineering to include material compatibility and materials selection for nuclear power systems. In-depth treatment of high-temperature corrosion, stress-corrosion cracking, and the effect of non-aqueous coolants. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

NSEG 5604:

Radiation Detect & Shielding

Radioactive decay, interaction of charged particles and photons with matter, methods of radiation detection and radiation dosimetry, counting statistics, external radiation protection using time, distance and shielding. Pre-requisite: Graduate Standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

NSEG 5904:

Project and Report

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research, Online Research

Instruction Type(s): Research, Online Research

Prerequisite(s):

Corequisite(s):

NSEG 5974:

Independent Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Independent Study, VI

Instruction Type(s): Independent Study, VI

Prerequisite(s):

Corequisite(s):

NSEG 5984:

Special Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

NSEG 5994:

Research and Thesis

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research, Online Research

Instruction Type(s): Research, Online Research

Prerequisite(s):

Corequisite(s):

NSEG 6124:

Adv Nuclear Reactor Analysis

Neutron transport theory. Neutron slowing down and resonance absorption. Neutron thermalization. Perturbation and variational methods. Homogenization theory. Space-time neutron kinetics.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): NSEG 5124 (UG)

Corequisite(s):

NSEG 6334:

Nuclear Reactor Safety

Hazards of nuclear reactors; analysis of hypothetical design basis accidents; engineered safeguards and safety design principles; nuclear criticality safety; reactor containment; reactor safety codes; and probabilistic risk assessment.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): NSEG 5114

Corequisite(s):

NSEG 6984:

Special Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

NSEG 7994:

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research, Online Research

Instruction Type(s): Research, Online Research

Prerequisite(s):

Corequisite(s):

PUBLIC HEALTH

Laura Hungerford, Head

Emeriti Faculty: Frank Pierson;

Professor: Jennifer Hodgson; Laura Hungerford; Kerry Redican;

Associate Professor: Andrea Bertke; Julia Gohlke; Kathryn Hosig; Patrick Pithua;

Assistant Professor: Charlotte Baker; Alasdair Cohen; Natalie Cook; Cornelia Deagle; Cassidy Rist; Jennifer Zambriski;

Associate Professor of Practice: Jacquelyn Pelzer; Valerie Ragan;

Assistant Professor of Practice: Sophie Wenzel;

General Contact: phs@vt.edu

Graduate Site: <https://publichealth.vt.edu/>

The Master of Public Health (MPH) is a professional degree that prepares graduates to practice public health in local, state, regional, national, and global settings. The Council on Education for Public Health (CEPH) accredits schools and programs in public health to ensure that their curriculum is appropriate to effectively prepare students to enter the public health workforce. Requirements include a supervised practice experience where the student assumes job functions in public health. Additionally, participation in a final culminating experience demonstrating competence in the field is required. Students in other graduate or professional degree programs often add the MPH degree to broaden their training and job prospects. In order for students to fully appreciate and assimilate the content, the 42-credit program is designed as a two-year, four-semester experience for full-time students with options for part-time, dual, and simultaneous degree studies. The program intentionally sequences the courses to ensure continuity in course materials and effective preparation for public health practice. Students formulate their plan of study with faculty advisors to include 19 core credits, 12 concentration credits, and 8 professional preparation credits. The MPH degree program offers two concentrations: public health education and infectious disease.

SPECIAL FACILITIES

The MPH program is primarily physically located in the Virginia-Maryland College of Veterinary Medicine (VMCVM) on the Virginia Tech campus. The majority of faculty and staff offices are located at the VMCVM, and the majority of MPH classes are held at the VMCVM. Additional program faculty have their offices adjacent to their labs in other Virginia Tech buildings, including the Integrated Life Sciences Building (ILSB) and the Center for One Health Research (COHR).

Virginia-Maryland College of Veterinary Medicine - Blacksburg campus

Address: 205 Duck Pond Drive (0442), Blacksburg, VA 24061

DEGREES OFFERED

MPH Degree

Offered In (Blacksburg)

GRE

Verbal: Recommended minimum (150.0)

Quantitative: Recommended minimum (150.0)

The 42-credit program is designed as a two-year, four-semester experience for full-time students with options for part-time, dual, and simultaneous degree studies. The program intentionally sequences the courses to ensure continuity in course materials and effective preparation for public health practice. Students formulate their plan of study with faculty advisors to include 19 core credits, 12 concentration credits, and 8 professional preparation credits. The MPH degree program offers two concentrations: public health education and infectious disease. For information on degree requirements, please visit our website or contact us at phs@vt.edu or 540-231-3945.

Degree Concentrations:

Public Health Education Concentration

Public Health Education Concentration Competencies: Upon completion of the MPH degree, graduates from the Public Health Education concentration will demonstrate proficiency in the main areas of responsibility defined by the National Commission for Health Education Credentialing (NCHEC): Area I: Assess Needs, Assets and Capacity for Health Education Area II: Plan Health Education Area III: Implement Health Education Area IV: Conduct Evaluation and Research Related to Health Education Area V: Administer and Manage Health Education Area VI: Serve as a Health Education Resource Person Area VII: Communicate and Advocate for Health and Health Education Public Health Education Concentration Courses: PHS 5214: Program Development in Health Education PHS 5204: Principles of Community Health Education PHS 5644: Program Evaluation PHS 5254: Social Epidemiology and Health Inequities

Infectious Disease Concentration

Infectious Disease Concentration Competencies: Demonstrate knowledge of infectious disease processes in individuals, including microbiology and pathogenesis of bacterial, viral, parasitic, and fungal organisms, and the host response. Design effective communication strategies to convey infectious disease information to a variety of audiences. Identify and evaluate the temporal and spatial dynamics of causes and risk factors for infectious diseases in populations. Describe and analyze host, agent, and environmental dynamics, including ecological, genetic, economic and social factors for infectious disease transmission in populations. Design interventions, policies, and

procedures for control and prevention of infectious diseases in communities and populations, including sources, dissemination, antimicrobial resistance, vaccines, food and water safety, and hospital-based infections. Develop evaluation plans for infection control and prevention applicable to broad variety of settings, from local community to global settings. Critically evaluate global health challenges that contribute to persistence of neglected infectious diseases and emergence of new infectious diseases. Apply public health and research concepts to One Health oriented interventions and studies, including the ability to critically assess current practices and research, define problems, and design strategies to eradicate and respond to infectious diseases. Infectious Disease Concentration Courses: PHS 5334: Principles of Infectious Disease PHS 5314: Infectious Disease Epidemiology PHS 5324: Public Health Infection Control and Prevention PHS 5344: Neglected and Emerging Infectious Diseases

GRADUATE COURSES (PHS)

PHS 5004:

Foundations of Public Health

Foundational principles of public health, including history, core functions and essential services. Public health ethics and values. Career opportunities in the public health core disciplines. Biologic determinants of health. Global and One Health frameworks for health and health professionals. Pre: Graduate standing.

Credit Hour(s): 1

Lecture Hour(s): 1

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PHS 5014 (VM 7014):

Environmental Health

Exploration of major environmental health concepts and issues, environmental policies and regulations. Topics include world population and pressures on the environment, healthy environment; environmental determinants of public health, including biological, physical and chemical factors; environmental factors affecting disease vectors and their control; air and water quality; waste management; the built environment, work environments and recreational area; food protection and safety; occupational health; tools for environmental evaluation, planning and safety. Pre: Graduate Standing or permission from the instructor.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PHS 5024:

Epidemiology and Quantitative Methods in Public Health Lab

Statistical skills needed to conduct epidemiologic and public health research including descriptive statistics, bivariate statistics, and regression. Reading and writing code. Manipulate, analyze, and visualize public health data using statistical software. Probability, confidence intervals, and significance. Statistical power. Pre: Graduate standing.

Credit Hour(s): 1

Lecture Hour(s):

Instruction Type(s): Lab, VB

Instruction Type(s): Lab, VB

Prerequisite(s):

Corequisite(s): PHS 5026

PHS 5025:

Epidemiology and Quantitative Methods in Public Health

5025: Investigation and analysis of dynamics and determinants of disease in communities and populations. Philosophy, assessment, and application of public health science, ethics, study design, data analysis, and epidemiologic measures. 5026: Basic ideas, methods, and measures of epidemiology. Statistical knowledge and skills to analyze and interpret data from epidemiologic studies. Introduction to common statistical packages. Evaluation of scientific evidence from literature. Identify and minimize major potential sources of error in epidemiologic studies. Pre: Graduate standing for 5025.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PHS 5026:

Epidemiology and Quantitative Methods in Public Health

5025: Investigation and analysis of dynamics and determinants of disease in communities and populations. Philosophy, assessment, and application of public health science, ethics, study design, data analysis, and epidemiologic measures. 5026: Basic ideas, methods, and measures of epidemiology. Statistical knowledge and skills to analyze and interpret data from epidemiologic studies. Introduction to common statistical packages. Evaluation of scientific evidence from literature. Identify and minimize major potential sources of error in epidemiologic

studies. Pre: Graduate standing for 5025.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): PHS 5025

Corequisite(s):

PHS 5034:

Health Behavior and Health Education

This course has two main purposes: (1) to familiarize students with historical, theoretical and methodological aspects of health psychology, and (2) to acquaint health education students with the social, psychological, and cultural determinants of health behaviors which form the underpinnings of health education practice.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PHS 5044 (HNFE 5694):

Public Health Policy and Administration

Multiple dimensions of the health policy-making process including the roles of ethics and evidence. Analyzing health policies for their impact on public health and health equity. Examining the structure and function of health care models nationally and globally. Constitutional basis for public health. Applying principles of planning, organizing, directing, staffing, and budgeting to public health agencies. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PHS 5054:

Public Health Leadership and Interprofessionalism

Fundamentals of public health leadership and management using a systems-thinking lens. Decision-making, change management, shared vision, and communication. Strategic planning and public health ethics. Negotiation role-playing. Models of team effectiveness. Team building applied to working on public health and interprofessional teams. Collaborative leadership, personal leadership styles, and self-reflection. Diversity and cultural competency in the public health setting as a leader. Pre: Graduate standing.

Credit Hour(s): 2

Lecture Hour(s): 2

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PHS 5204:

Principles of Community Health Education

Public health issues and concepts are analyzed and evaluated in relationship to existing principles of health education.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PHS 5214 (HNFE 5684):

Program Development in Health Education

Theory, trends, and design of community health education programs implemented in communities, health agencies, hospitals, and industry.

Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PHS 5224:

Comp Health Systems

Comprehensive examination of the structure and function of worldwide healthcare and public health systems. National health services with central funding, social insurance programs, decentralized systems, and private insurance systems. Pre-requisite: Graduate Standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PHS 5244:

Sexual Health and Human Rights

Sexual and reproductive health from human development, public health, and critical feminist perspectives, with special attention to human rights

issues. Sexually transmitted infections; HIV/AIDS; unintended pregnancy; population policies; eugenics; sexual and reproductive rights; positive sexuality, sex education; and health promotion. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PHS 5254:

Social Epidemiology and Health Inequities

Social determinants of health through the life-course. Relationship of social injustice to public health. Interplay of major social factors such as poverty, race and gender to influence health domestically and globally. Application of social epidemiology to a range of health outcomes. Inform effective solutions to health inequities. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PHS 5304:

Zoonoses and Infectious Diseases Common to Humans and Animals

Epidemiology of bacterioses, mycoses, chlamydioses, rickettsioses, parasitosis, viroses and prion diseases that are transmissible between animals and humans and/or are acquired by animals and human from the same source and that have great impact on public health. Cultural, social and economic factors and impacts; modes of inter - and intra-species transmission including roles of vectors and environmental factors; concepts of emergence and re-emergence; pathogenesis in various hosts and host adaptation; temporal and spatial dynamics and risk factors for exposure, infection and expression of clinical disease; modes of detection, control/mitigation and prevention; biosecurity, including food safety and security. Prerequisite: Graduate Standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PHS 5314 (VM 7314):

Infectious Disease Epidemiology

Dynamics and determinants of infectious diseases and their assessment on the molecular to population continuum in a systems based approach. Infectious disease transmission mechanisms; population susceptibilities; environmental, social, cultural and economic contributors to infectious disease propagation; detection and surveillance; geographic information systems; epidemiologic study design; and infectious disease modeling.

Prerequisite: Graduate Standing required

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PHS 5324 (VM 9324):

Pub Hlth Infect Contrl & Prev

Assessment, policies, and procedures for control and prevention of infectious diseases in communities and populations. Sources, transmission mode, and local community to international dissemination of infectious disease agents; antimicrobial and chemical resistance; vaccine development, safety, and coverage; community and hospital based needs and interventions; and regulatory frameworks. Pre: Graduate Standing required.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PHS 5334 (VM 9334):

Principles of Infectious Diseases

Principles of infectious diseases important for local, national, and global public health. Bacterial, viral, fungal, and parasitic pathogens; mechanisms of disease; host immune response to pathogens. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PHS 5344 (VM 9344):

Neglected infectious diseases and their association with marginalized populations and factors including poverty, social and health inequities, water, sanitation and hygiene, and urbanization. Critical factors for emergence/re-emergence of infectious diseases in populations and regions, including geopolitical challenges, zoonotic and vector impacts. Evaluate studies and global responses to neglected and emerging infectious diseases to inform the development of One Health interventions. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PHS 5354:

Modeling Infectious Diseases

Mathematical modeling of infectious diseases in humans and animals. Deterministic susceptibles-infectious-recovered (SIR) and related models, estimation of reproductive number, host heterogeneities, multi-pathogen/multi-host models, spatio-temporal models, stochastic dynamics, and modeling for public health policy. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PHS 5644 (HD 5644):

Program Evaluation

Methods of conducting program evaluations for prevention and intervention programs that promote public health and human development. Major dimensions of evaluation strategies, including process evaluation, impact assessment, and cost analysis. Pre: Graduate Standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PHS 5704 (CEE 5704):

Drinking Water & Health

Drinking water contamination and associated health outcomes. Programs to improve safe water access. Viral, bacterial, protozoal, and

helminthic pathogens. Heavy metals, pesticides, and other contaminants. Drinking water treatment and supply in rural areas. Study designs for health outcome assessment. Field-based intervention trials. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PHS 5714:

Health of the Elderly

The health needs and problems of the elderly, the implications for those working with the elderly, and possible health care delivery systems.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PHS 5904:

Project and Report

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s):

Instruction Type(s): Research, Online Research

Instruction Type(s): Research, Online Research

Prerequisite(s):

Corequisite(s):

PHS 5914:

Practicum in Public Health

Public health theories and concepts in a work setting; comprehensive, structures experience requires student to demonstrate professional competencies while working closely with a supervisor in a public health practice setting. Pre-requisite: Graduate Standing and completion of 24 hours of MPH degree coursework.

Credit Hour(s): 6

Lecture Hour(s): 6

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

Capstone in Public Health

Synthesis of coursework and practicum experience into a final comprehensive product which integrates knowledge and skills acquired in all core classes, specific MPH concentration courses and practicum experience for developing, implementing and evaluating a public health program; tests students ability to effectively analyze a public health problem and develop an intervention toward a solution to the problem.

Pre-requisite: Graduate standing; completion of 39 hours of MPH coursework including enrollment in or completion of public health practicum.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PHS 5934:

Public Health Integrative Learning Experience

Culminating experience required for the MPH degree. Integration of program foundational and concentration-specific competencies. Team-based public health educational and professional experience.

Addressing a public health challenge. Working with a mentor from an external stakeholder organization. Producing individual high-quality written deliverable. Reflection on the learning experience. Team presentation of project. Pre: Graduate standing.

Credit Hour(s): 3

Lecture Hour(s): 3

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PHS 5935:

Preparation for Public Health Practice

Preparation for the public health profession. Covers the necessary skills to become a successful public health professional. 5935: Exploration of Public Health Practice Experience (PHPE) placement opportunities. PHPE goals, objectives, and competencies. PHPE products that align with academic and professional goals. PHPE learning contract.

Institutional review board (IRB) protocols. Communications and professionalism skills. Academic poster and e-portfolio design. Work/life balance strategies. 5936: Examination of professional preparation for careers in public health. Job search strategies, resume/CV and cover letter writing, interviewing, and networking. Workplace skills, including professional communication, group process, leadership/supervision skills, working with the media, and survey design and data presentation.

Personal/professional growth strategies, including salary and benefits negotiation, debt management, and time management. Grant writing.

Pre: Graduate standing; 5935 for 5936. Pass/Fail only.

Credit Hour(s): 1

Lecture Hour(s): 1

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PHS 5936:

Preparation for Public Health Practice

Preparation for the public health profession. Covers the necessary skills to become a successful public health professional. 5935: Exploration of Public Health Practice Experience (PHPE) placement opportunities.

PHPE goals, objectives, and competencies. PHPE products that align with academic and professional goals. PHPE learning contract.

Institutional review board (IRB) protocols. Communications and professionalism skills. Academic poster and e-portfolio design. Work/life balance strategies. 5936: Examination of professional preparation for careers in public health. Job search strategies, resume/CV and cover letter writing, interviewing, and networking. Workplace skills, including professional communication, group process, leadership/supervision skills, working with the media, and survey design and data presentation.

Personal/professional growth strategies, including salary and benefits negotiation, debt management, and time management. Grant writing.

Pre: Graduate standing; 5935 for 5936. Pass/Fail only.

Credit Hour(s): 1

Lecture Hour(s): 1

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): PHS 5935

Corequisite(s):

PHS 5964:

Practicum

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PHS 5974:

Independent Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Independent Study, VI

Instruction Type(s): Independent Study, VI

Prerequisite(s):

Corequisite(s):

PHS 5984:

Special Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

PHS 8984:

Special Study

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

REGENERATIVE MEDICINE

Professors: Linda Dahlgren; Rafael Davalos; Sally Johnson;

Associate Professors: Jennifer Barrett; Christopher Byron; Aaron Goldstein;

William Huckle; Mark Van Dyke; Vincent Wang; Abby Whittington;

Assistant Professors: Sophie Bogers; Jia-Qiang He; Ashley Heflin; Blake

Johnson; Paul Morton; Michelle Theus; Eli Vlasisavljevic;

Adjunct Professors: Willard Eyestone;

College of Veterinary Medicine: Jennifer Barrett; Sophie Bogers; Christopher

Byron; Linda Dahlgren; Willard Eyestone; Jia-Qiang He; William Huckle; Paul

Morton; Michelle Theus;

College of Engineering: Rafael Davalos; Aaron Goldstein; Blake Johnson; Mark

Van Dyke; Eli Vlasisavljevic; Vincent Wang; Abby Whittington;

College of Liberal Arts & Human Sciences: Ashley Heflin;

College of Agriculture and Life Sciences: Sally Johnson;

Aaron Goldstein: goldst@vt.edu

Linda Dahlgren: lad11@vt.edu

Graduate Site: <http://www.regenmed.vetmed.vt.edu>

Regenerative medicine (RM) is a new medical approach that seeks to restore both structure and function of tissues lost to injury, disease or congenital defects. This field incorporates use of stem cells, proteins that stimulate healing, and engineered biomaterials to help cure diseases from diabetes to osteoarthritis. Regenerative strategies are modeled on mechanisms drawn from embryonic development and naturally-occurring examples of regeneration. This field represents a paradigm shift in biology, medicine and biomedical engineering. Ethical and societal impacts need to be considered as this rapidly expanding technology is developed. Furthermore, the swift translation of these technologies to the clinical realm provokes a need for both public policy considerations and practical feasibility from a business perspective. Leaders in RM must have training, understanding and interactions across diverse disciplines. The Regenerative Medicine Interdisciplinary Graduate Education Program (IGEP) team aims to produce leaders in RM by training students in the broad complexities inherent to the field, beyond expertise gained in their specific disciplines. The IGEP will be among the first programs of its kind to equip students with a broad-based, graduate-level education in the field of RM. Colleges and Departments: College of Veterinary Medicine Biomedical Sciences and Pathobiology Large Animal Clinical Sciences Small Animal Clinical Sciences College of Engineering Materials Science and Engineering Chemical Engineering Engineering Science and Mechanics Biomedical Engineering and Mechanics College of Liberal Arts and Human Sciences Science and Technology in Society College of Business Marketing Management For more information please contact Principal Investigators Linda Dahlgren (lad11@vt.edu) or Aaron Goldstein (goldst@vt.edu) or visit our website.

SPECIAL FACILITIES

The program takes advantage of access to facilities within all of the four programmatic areas.

Goodwin Hall

Goodwin Hall is the flagship building for the College of Engineering. It houses 40 instructional and research labs, eight classrooms, the Quillen Family Auditorium, and 150 offices for several engineering departments. More than classrooms, offices, and laboratories, Goodwin Hall is a ground-breaking experiment to measure even the smallest vibrations made inside the building. The project is designed as a test bed to track data related to building design and security, occupancy monitoring for emergency response, structural health monitoring, and more. Roughly 240 accelerometers attached to 136 sensor mounts throughout the building's ceilings will detect information on where people are within the structure, measure normal structural settling and wind loads, and track building movement resulting from earthquakes similar to the event that struck Virginia in 2011. A sensor array mounted outside the building will measure external vibrations, such as wind, the bustle of traffic on nearby Prices Fork Road, the thunderous boom of tens of thousands of Hokie fans celebrating a touchdown at Lane Stadium, and possible seismic activity.

Integrated Life Sciences Building

The Integrated Life Sciences Building is a flagship building of the Fralin Life Science Institute, an investment institute committed to supporting research, education, and outreach in Virginia Tech's life sciences community.

Kelly Hall

Opened in 2009, Kelly Hall houses the Institute for Critical Technology and Applied Science, which supports and promotes cutting-edge research at the intersection of engineering, science, and medicine. The building includes engineering-led research laboratories, offices, and workspaces.

Marion duPont Equine Medical Center

The Marion duPont Scott Equine Medical Center is a premier, full-service equine hospital located in Leesburg, Virginia, and one of two hospitals of the Virginia-Maryland College of Veterinary Medicine. We offer advanced specialty care, 24-hour emergency treatment, and diagnostic services for all ages and breeds of horses. Our team of equine specialists in internal medicine, reproduction, sports medicine and rehabilitation, and surgery is committed to providing exceptional treatment for patients; superior service to clients; education for referring veterinarians, future veterinarians, and clients; and cutting-edge research to the equine industry.

Virginia-Maryland College of Veterinary Medicine

Established in 1978. The college is a leading biomedical teaching and research center and the in-state veterinary college for residents of Virginia and Maryland. Locations include the main campus in Blacksburg, Virginia, the Marion duPont Scott Equine Medical Center in Leesburg, Virginia, and the Gudelsky Veterinary Center in College Park, Maryland.

DEGREES OFFERED

IGEP Degree

Offered In (Blacksburg, Leesburg)

TOEFL

Paper: (550.0)

iBT: (80.0)

Regenerative Medicine is not a degree-granting program.

REMOTE SENSING

Randolph Wynne, Program Director

Professors: Thomas Burbey; James Campbell; William Hession; Richard Hirsh; Eric Patterson; Layne Watson; Randolph Wynne;

Associate Professors: Amos Abbott; Scott Bailey; Joseph Baker; Saul Halfon;

Kevin Kochersberger; Klaus Moeltner; Thomas Pingel; John Ruohoniemi; Valerie Thomas;

Assistant Professors: Xinwei Deng; Anuj Karpatne; Elena Lind; Yang Shao; Robert Thomas;

Rolls-Royce Commonwealth Professor of Marine Propulsion: Eric Patterson;

Randolph Wynne: wynne@vt.edu

Valerie Thomas: thomasv@vt.edu

Joseph Baker: jo.baker@vt.edu

Graduate Site: <https://www.rsigep.frec.vt.edu>

Remote sensing provides technical and methodological approaches to holistically study human activities that have an impact on the Earth's physical processes. Ever-increasing natural and anthropogenic influences on the earth system necessitate the formation of a cadre of scientists well-trained to fully exploit the terabytes of information available daily from air- and space-borne sensors. While the information resulting from analysis of these data is, by itself, policy relevant, only by combining the information available from remote sensing with the knowledge, approaches, and analytical tools of the social sciences can complex issues at the interface of science and society be addressed. Further, remote sensing itself engenders a variety of social and policy questions, ranging from personal privacy to the social and cultural change that inevitably results from the wide adoption of transforming technology. The goal of this program is to provide fully integrated educational experiences that will strengthen and enhance the ability of our graduates to address interdisciplinary challenges facing remote sensing scientists in today's workplace. We do this by incorporating all aspects of remote sensing, including science, engineering, theory, data analysis, applications, and policy. Our internationally-recognized faculty members span 5 colleges and 13 departments at Virginia Tech: College of Engineering Aerospace and Ocean Engineering (AOE) Biological Systems Engineering (BSE) Computer Science (CS) Electrical and Computer Engineering (ECE) Mechanical Engineering (ME) College of Natural Resources and Environment Forest Resources and Environmental Conservation (FREC) Geography (GEOG) College of Agriculture and Life Sciences Agricultural and Applied Economics (AAEC) Biological Systems Engineering (BSE) College of Liberal Arts and Human Sciences History (HIST) Science and Technology Studies (STS) College of Science Geosciences (GEOS) Biological Sciences (BIOL) Statistics (STAT)

SPECIAL FACILITIES

Advanced Research Computing

Advanced Research Computing (ARC) delivers a comprehensive ecosystem consisting of advanced computational systems, large-scale data storage, visualization facilities, software, and consulting services.

Center for Environmental Analytics and Remote Sensing

The CEARS laboratory is equipped with 22 networked (1 Gbit) precision workstations (15 Quad core Xeon with 64 Gb ram, 7 Six core Xeon with 128 Gb ram) a high end large format printer, and a complete suite of image processing (ENVI, ERDAS Imagine) and associated software, including compilers (IDL, Fortran), numerical scripting environments

(Matlab, Julia, Python), statistical packages (R, SAS, Minitab, Salford Predictive Miner), structure from motion photogrammetric processing (DroneDeploy, Pix4D) and GIS (QGIS and ESRI products). There is over 100 TB of local networked attached storage (backed up daily). Capability for measuring and integrating in situ and unmanned airborne measurements is provided by UAS lidar (YellowScan; joint with BSE), full range ASD spectroradiometers, roving GPS base stations, and a wide variety of commercial off the shelf sUASs.

Space@VT

Space@VT focuses on research investigations of the science, technological impact, and utilization of the geo-space environment. The goal of Space@VT is to develop a holistic approach to such research utilizing theoretical and advanced computational modeling as well as the development of scientific instruments and space missions for experimental data acquisition and analysis. Research Facilities Global Navigation Satellite System GNSS Laboratory Space Systems Simulation Laboratory Aeronomy/Remote Sensing Laboratory Advanced Space Computation Laboratory SuperDARN Space Weather Radar Facility Space Plasma Chamber

DEGREES OFFERED

IGEP Degree

Offered In (Blacksburg)

TOEFL

iBT: (90.0)

GRE

General: Verbal, Quantitative, Analytical

The Interdisciplinary Graduate Education Program in Remote Sensing requires all students to be accepted by and enrolled in a home program in one of the following core participating departments/programs (colleges in parentheses): Aerospace and Ocean Engineering (Engineering) Agricultural and Applied Economics (Agriculture and Life Sciences) Biological Sciences (Science) Biological Systems Engineering (Agriculture and Life Sciences, Engineering) Computer Science (Engineering) Electrical and Computer Engineering (Engineering) Forest Resources and Environmental Conservation (Natural Resources and Environment) Geosciences (Science) Geospatial and Environmental Analysis (Natural Resources and Environment) Mechanical Engineering (Engineering) Science and Technology Studies (Liberal Arts and Human Sciences) Statistics (Science) It is essential that students applying to the Remote Sensing IGEP designate their desired home program on their application so that the materials can be appropriately routed for joint evaluation. In addition to participating in IGEP-specific events and meetings, enrolled students must meet all requirements of their home program and the Remote Sensing Certificate, plus enroll in either GRAD 5134 (Interdisciplinary Research in Remote Sensing) or the Interdisciplinary Seminar in Remote Sensing (FOR/GEOG 5104 or equivalent) if offered, each semester in which they are enrolled on campus. A lab exchange is required, either on- or off-campus. Most students elect the off-campus option with federal scientists at a national lab, NASA Center, or other agencies. Co-chairing of advisory

committees is considered to be the norm; exceptions must be granted by the program director in consultation with the major professor and home department.

SUSTAINABLE NANOTECHNOLOGY

Professors: Linsey Marr; Amy Pruden-Bagchi; Peter Vikesland;

Associate Professors: Earl Foster; Maren Roman;

Assistant Professors: Guoliang Liu; Frederick Michel;

Research Faculty: Weinan Leng;

Nick Prillaman Professor: Peter Vikesland;

Charles P. Lunsford Professor: Linsey Marr;

W. Thomas Rice Professor: Amy Pruden-Bagchi;

Research Associate Professors: Sean McGinnis;

Research Assistant Professors: Matthew Hull;

Peter Vikesland: pvikes@vt.edu

Graduate Site: <http://www.sun.ictas.vt.edu>

The focus of the SuN IGEP is to develop a new paradigm wherein the sustainability of a given nanotechnology is considered during its entire life cycle. The primary research goal of the SuN IGEP is to facilitate the incorporation of sustainable design concepts in the nanotechnology field.

The sustainability of a particular technology is often an afterthought in the design process; however, because nanotechnology is still in its infancy there is significant potential to proactively direct the field towards sustainable design. The primary educational goal of the SuN IGEP is to produce doctoral graduates that have the skills and expertise to provide leadership in the interdisciplinary field of sustainable nanotechnologies. This IGEP builds upon the existing infrastructure of the ICTAS VTSuN Center of Excellence, the NSF/EPA supported Center for the Environmental Implications of Nanotechnology (CEINT), and the EIGER NSF IGERT and the Green Engineering programs at Virginia Tech. Collectively these interdisciplinary efforts provide the intellectual focus and background for our IGEP group. Colleges and Departments: College of Engineering Civil and Environmental Engineering Materials Science and Engineering College of Natural Resources and Environment Sustainable Biomaterials College of Science Departments Geosciences Chemistry For more information please contact Peter Vikesland, Principal Investigator, pvikes@vt.edu

SPECIAL FACILITIES

The SuN IGEP investigators maintain laboratories in each of their individual departments. Details about these laboratories can be found at the individual investigator websites. A summary of the VTSuN program may be found at the VTSuN website: <http://www.sun.ictas.vt.edu>

Kelly Hall Laboratories

The VTSuN IGEP maintains extensive laboratories within Kelly Hall. The instrumentation available in these labs is described on the VTSuN webpage.

DEGREES OFFERED

IGEP Degree

Offered In (Blacksburg)

TOEFL

Paper: (550.0)

iBT: (80.0)

GRE

VT SuN is not a degree-granting program.

TRANSLATIONAL BIOLOGY, MEDICINE, AND HEALTH

Michael Friedlander, Head

Professors: Luke Achenie; S Ahmed; Katherine Allen; Joyce Arditti; Josep Bassaganya-Riera; Martha Ann Bell; Warren Bickel; Rosemary Blieszner; Paul Carlier; Daniel Crawford; Rafael Davalos; George Davis; Richey Davis; Kevin Davy; Dennis Dean; Harry Dorn; Felicia Etzkorn; Edward Ewing; Wu-Chun Feng; Michael Friedlander; Hampton Gabler; Harold Garner; Robert Gourdie; Bernice Hausman; Lenwood Heath; Thomas Inzana; Honglin Jiang; Peter Kennelly; Mahmood Khan; David Kingston; Liwu Li; David Lindsay; Dongmin Liu; Timothy Long; Achla Marathe; Xiang-Jin Meng; Joseph Merola; Pendleton Montague; Maury Nussbaum; Craig Ramey; Sharon Ramey; Kerry Redican; Jeffrey Reed; Karen Roberto; Harald Sontheimer; Danesh Tafti; James Tanko; Pamela Teaster; Zhijian Tu; John Tyson; Yue Wang; Layne Watson; Richard Winett; Doris Zallen; Anisa Zvonkovic;

Associate Professors: Zachary Adelman; Masoud Agah; Kathleen Alexander; Sheryl Ball; Jennifer Barrett; Daniel Capelluto; Daniela Cimini; Sarah Clinton; Lee Cooper; Linda Dahlgren; Megan Dolbin-MacNab; Julie Dunsmore; Alan Ealy; April Few-Demo; Carla Finkelstein; Michael Fox; Deborah Good; Robert Grange; David Harrison; Richard Helm; Kathryn Hosig; William Huckle; Matthew Hulver; Sally Johnson; Christine Kaestle; Isis Kanevsky; Jungmeen Kim-Spoon; Michael Klemba; Stephen LaConte; Kevin Lahmers; Christopher Lawrence; Maria Lazar; Yong Lee; Stephen Melville; Ignacio Moore; Rolf Mueller; Biswarup Mukhopadhyay; Kevin Myles; Nadarajah Nanthakumar; Yuchin Pan; Robin Panneton; Steven Poelzing; Robin Queen; Padmavathy Rajagopalan; Robert Rhoads; Webster Santos; Jyoti Savla; Angela Scarpa-Friedman; Eva Schmelz; Elena Serrano; Igor Sharakhov; Cynthia Smith; Pablo Sobrado; Elankumaran Subbiah; Mark Van Dyke; Pamela VandeVord; Vincent Wang; Susan White; Hehuang Xie; Jianhua Xuan; Wen You; Lijuan Yuan; Jinsong Zhu; Jamie Zoellner;

Assistant Professors: Kaja Abbas; Irving Allen; Fabio Almeida; Troy Anderson; Bahareh Behkam; Andrea Bertke; Lissett Bickford; Jerald Bowers; Guohua Cao; Maria Cassera; Clayton Caswell; John Chappell; Jing Chen; Zhiyong Cheng; Pearl Chiu; Mark Cline; Nikolaos Dervisis; Samer El-Kadi; Luis Escobar Quinonez; Madlyn Frisard; Elizabeth Gilbert; Julia Gohlke; Erika Grafsky; Samantha Harden;

Silke Hauf; Jia-Qiang He; Timothy Jarome; Blake Johnson; Caroline Jones; Jatinder Josan; Benjamin Katz; Deborah Kelly; Brooks King-Casas; Shihoko Kojima; Nathan Lau; Kiho Lee; Xin Luo; William Mather; John Matson; Alexei Morozov; Konark Mukherjee; Amrinder Nain; Zachary Nimchuk; Kenneth Oestreich; Alicia Pickrell; John Richey; Stefanie Robel; Birgit Scharf; Kendra Sewall; Zhi Sheng; Daniel Slade; James Smyth; Divya Srinivasan; Michelle Theus; Gregorio Valdez; Scott Verbridge; Sujith Vijayan; Bin Xu;

University Distinguished Professor: Dennis Dean; Karen Roberto;

Alumni Distinguished Professor: Rosemary Blieszner;

Research Assistant Professors: Sarah Parker;

Graduate Contact: guyenn@vt.edu

Graduate Site: <http://www.tbmh.vt.edu/>

The TBMH program has been designed to help address a national need for accelerating the pace of translation of biomedical discoveries into diagnostics, treatments, and cures, as well as their effective implementation. Major national organizations, such as the National Institutes of Health, Association of American Medical Colleges, and the Federation of American Societies for Experimental Biology, have called for new approaches to train biomedical and health scientists to achieve this goal, recognizing that today's researchers must utilize interdisciplinary approaches, communicate across levels of inquiry, and be prepared for the diverse careers that drive today's biomedical research enterprise. Graduates of the TBMH program will be well prepared to take on these challenges and become tomorrow's scientific leaders. Through a combination of TBMH core and focus area-specific coursework, students will be trained to go deep at advanced levels in a particular area (just as in classic disciplines), but also to have the skills, confidence and intellectual breadth to identify today's pressing health issues, and develop them in the framework and context of greater needs. This includes recognizing the likelihood of the adoption and application of translational discoveries, their cost, delivery, and related policy issues. Students may specialize in one of six focus areas: Cancer Tissue Engineering and Reparative Medicine Public Health Implementation Science Immunity and Infectious Disease Metabolic and Cardiovascular Science Neuroscience (Cognitive or Molecular) Regardless of the focus area in which the students specialize, all graduates of the TBMH program will be able to: Explain the stages of the translational research spectrum Evaluate how multiple complex cellular and molecular factors influence physiological systems Integrate and model the processes of healthful function across scales, from the molecular to the organismal, and the individual to the social network Evaluate and compare published claims for the capacity to prevent or alter trajectories of unhealthy biological processes through genetic, pharmacological, behavioral and health systems interventions Conceive new conceptual approaches or technological strategies for the identification and quantification of pathological processes, their prevention or treatment, and/or the effective implementation of such interventions. Demonstrate effective written and oral communication of scientific concepts and data in translational biology, medical and health research. Work collaboratively in an interdisciplinary environment, which may include basic scientists, translational scientists, clinicians, administrators, or policy makers. Identify career opportunities for biomedical and translational scientists, and conduct one's chosen professional activities in a responsible and ethical manner

SPECIAL FACILITIES

According to the National Science Foundation annual survey of over 900 institutions, Virginia Tech continues to rank in the top 5 percent of colleges and universities in research and development expenditures. The university received almost \$300 million in grant awards in FY2012, and over \$450 million in research expenditures over that same year. Virginia Tech is ideally positioned to train the next generation of translational scientists to fulfill the innovative, interdisciplinary, and collaborative research needs of the future, as it merges strengths in the life sciences, social sciences, bioinformatics, and engineering, with an expanding biomedical and health research enterprise. This includes a recent \$150 million investment in the Virginia Tech Carilion School of Medicine and Research Institute, located in Roanoke, Virginia. Due to the interdisciplinary nature of the program and the diversity of the faculty mentors and instructors (including clinical faculty who will instruct in courses and participate in student thesis advisory committees), students will have access to a broad range of Virginia Tech's research and instructional facilities located in both Blacksburg and Roanoke. Participating colleges include: College of Agriculture and Life Sciences College of Engineering, including the Virginia Tech Wake Forest University School of Biomedical Engineering and Sciences College of Liberal Arts and Human Sciences College of Natural Resources and Environment College of Science College of Veterinary Medicine Virginia Tech Carilion School of Medicine Students have the opportunity to participate in research rotations with three different research groups before selecting a thesis mentor, and may select from participating faculty at Virginia Tech's facilities in Blacksburg or Roanoke. The two campuses are conveniently interconnected through a free university shuttle system with onboard wireless internet, as well as via the Smart Way Commuter Bus. Both locations also utilize state of the art interactive videoconferencing technology to assist with multi-site course instruction and student thesis committee meetings, as well as for transmitting visiting guest lectures and seminar series between campuses.

DEGREES OFFERED

PhD Degree

Offered In (Blacksburg, Roanoke)

Students pursuing a TBMH Ph.D. degree must earn a minimum of 100 credit hours beyond the baccalaureate, including 31 credits of core coursework, 6 credits of elective coursework, and 63 credits of research and dissertation. An M.S. degree is not required for admission to the program, though students with an M.S. are also eligible to apply. All coursework must be 5000-level and above. Students perform three research rotations before selecting a thesis mentor at the end of the second semester of study. Students must select one of the program's "Focus Areas" by the end of the first semester. Candidates are eligible for graduation upon successful completion of all core, elective, and research credits, as well as passing performance on the Qualifying Examination, Preliminary Examination (advancement to candidacy), and successful oral defense of a written dissertation. Course Requirements: All students will be required to take the following core classes (31 credits): TBMH 5004 Translational Biology, Medicine, and Health (8 credits) TBMH 50X4 Fundamentals in [Focus Area 1] (4 credits) TBMH 50X4 Fundamentals in [Focus Area 2] (4 credits) TBMH 5105 Professional Development and Ethics (2 credits) TBMH 5106 Professional Development and Ethics (2 credits) TBMH 5304 Research Experience in TBMH (2 x 3 credits = 6 credits) TBMH 5204 Seminar in Translational Biology, Medicine and Health (4 x 1 credits = 4 credits) TBMH 5404 Scientific Logic and Analysis (1 credit) In addition, students must take the following: Quantitative Elective (3 credits) Free Elective (3

credits) TBMH 7994 Research and Dissertation (63 credits)

Degree Concentrations:

Cancer

Students entering this focus area will have an interest in eliminating the suffering and death due to cancer, through research in cancer prevention, early diagnosis, and treatment interventions. Focus area-specific coursework will take an integrative, translational approach to all aspects of neoplastic disease, from its basis in molecular cell biology (including genetics, stem cells, invasion and metastasis, immune surveillance) to its diagnosis and treatment (biomarkers, drug design, screening, personalized medicine, surgical approaches), as well as its social, psychological, and economic consequences. Students will develop a solid foundation for pursuing interdisciplinary doctoral level research in cancer biology.

Tissue Engineering and Reparative Medicine

Students entering this focus area will have an interest in promoting a better quality of life through research into the biomedical and behavioral components of development and aging, as well as cutting edge technologies and methodologies for improving health in cases of developmental or age-related disorders and injuries. This focus area will emphasize processes critical to human biology and well-being across the lifespan. Students will develop a strong understanding of critical genetic, cellular, molecular, physiological, environmental and psychological aspects of human development, and how these processes go awry with aging, in order to best address how to repair them. Students will learn about multiple systems and techniques (including regenerative medicine). Faculty from diverse departments will come together to instruct students on the biological, psychological, social, and public policy components of the development and aging populations, as well as state of the art reparative approaches. Graduates will be well prepared to carry out innovative, interdisciplinary research to address critical challenges facing our developing and aging populations.

Public Health Implementation Science

Health Implementation Science is an emerging field strongly endorsed by the National Institutes of Health, The Institute of Medicine, and The National Research Council. It is located at far end of the clinical translational continuum -- focused on scientific inquiry about the "uptake" of major medical and health discoveries by practitioners and policymakers and their impact on the well-being of individuals and communities. Historically, the lag time from discovery of a major efficacious treatment to its actual clinical implementation has been estimated as 17 years, and many highly efficacious, affordable treatments are being implemented improperly, incompletely, and/or inequitably, thus failing to realize the benefits anticipated. Above all, there is grave concern that the mega-investments in basic science and clinical research are not yielding their full impact. In a now-seminal New

England Journal of Medicine article, Zerhouni (2005), then Director of the National Institutes of Health, called for corrective action by creating “a new, vital, and reinforced academic discipline and home for translational and clinical science — along with an explicit effort to maximize the effectiveness of NIH resources directed to this area of research — to ensure that extraordinary scientific advances of the past decade will be rapidly captured, translated, and disseminated for the benefit of all Americans.” Students in the Health Implementation Science focus area will learn the basic terminology and approaches from a range of specialty fields -- including health literacy, information dissemination, health systems research, public health, community-based participatory research, health economics, and health disparities research – and explicitly connect them to conduct implementation science. Students will engage in case studies from all of the major basic biology, medicine, and health fields to understand the pathway from discovery of efficacious treatments or preventive interventions to their extension to clinical practice and the measurement of patient-oriented outcomes.

Immunity and Infectious Disease

Students entering this focus area will have an interest in performing research towards the understanding, prevention, and treatment of infectious and immunologic diseases. Track-specific coursework will take an integrative, translational approach to all aspects of infectious disease. They will learn about and discuss contemporary and emerging pathogens (viral, bacterial, and other), the human immune response, the development and delivery of novel diagnostics and therapeutics, as well as the social, psychological, and economic consequences of infectious and immune diseases. Students will develop a professional level of expertise in immunity and infectious disease, and learn to apply this knowledge to carry out innovative and interdisciplinary research to advance disease prevention, diagnostics and treatment.

Metabolic and Cardiovascular Science

Students entering this focus area will have an interest in improving health and quality of life through research on cardiovascular and metabolic health. Students will develop a comprehensive understanding of metabolic and cardiovascular physiology, and their interrelationship. This will include topics such as principle energy systems, appetite and energy expenditure, and cardiovascular function and regulation. Similar to other focus areas in the program, they will perform extensive analysis of primary literature and case studies covering the epidemiology, pathophysiology, and socioeconomic impact of cardiometabolic diseases (such as diabetes, obesity, and heart disease) with an emphasis on the translation of basic scientific discoveries into practical applications.

Neuroscience

Students entering this focus area will have an interest in reducing the burden of neurological and mental health disorders through research. Students will develop an understanding of the normal biological processes that undergird healthy brain and cognitive function, the

causes and mechanisms of dysregulation that lead to dysfunction, and current and evolving approaches to therapy and novel therapeutic development. They will explore the inter-relationships of these processes at multiple levels at the intersection of brain biology, behavior, cognition, medicine and health and develop a strong foundation for pursuing doctoral level research in the brain and cognitive sciences. Students can choose to focus in Cognitive Neuroscience or Molecular Neuroscience.

MS Degree

Offered In (Blacksburg, Roanoke)

Students pursuing a TBMH M.S. degree must earn a minimum of 38 credit hours beyond the B. S. degree. Students will engage in research throughout both years in the program, while completing most of their core coursework by the end of year 1. Students will take an intensive “Gateway” course (TBMH 5004, 8 credits) in semester 1, where they will learn the fundamentals of biomedicine, physiological systems, and translational science. They will then select a focus area in semester 2 and take an equally intensive “Fundamentals” course (8 credits) covering in depth the fundamentals of that focus area, with heavy emphasis on translational exemplars and case studies. The six focus areas are: Neuroscience; Cancer; Health Implementation Science; Metabolic and Cardiovascular Science; Immunity and Infectious Disease; and Development, Aging, and Repair. Students will continue a core curriculum in parallel with their focus-area-specific coursework, which includes professional development, ethics, and statistics, as well as program retreats and presentations. In total, students will take 24 credits of core coursework, 3 credits quantitative requirement, and a minimum of 11 credits of thesis research. Course Requirements: All students will be required to take the following core classes (24 credits): TBMH 5004 Translational Biology, Medicine, and Health (8 credits) TBMH 50X4 Fundamentals in [Focus Area 1] (4 credits) TBMH 50X4 Fundamentals in [Focus Area 2] (4 credits) TBMH 5105 Professional Development and Ethics (2 credits) TBMH 5304 Research Experience in TBMH (2 x 3 credits = 6 credits) In addition, students must take the following: Quantitative Elective (3 credits) TBMH 5994 Research and Dissertation (11 credits)

Degree Concentrations:

Cancer

Students entering this focus area will have an interest in eliminating the suffering and death due to cancer, through research in cancer prevention, early diagnosis, and treatment interventions. Focus area-specific coursework will take an integrative, translational approach to all aspects of neoplastic disease, from its basis in molecular cell biology (including genetics, stem cells, invasion and metastasis, immune surveillance) to its diagnosis and treatment (biomarkers, drug design, screening, personalized medicine, surgical approaches), as well as its social, psychological, and economic consequences. Students will develop a solid foundation for pursuing interdisciplinary research in cancer biology.

Tissue Engineering and Reparative Medicine

Students entering this focus area will have an interest in promoting a

better quality of life through research into the biomedical and behavioral components of development and aging, as well as cutting edge technologies and methodologies for improving health in cases of developmental or age-related disorders and injuries. This focus area will emphasize processes critical to human biology and well-being across the lifespan. Students will develop a strong understanding of critical genetic, cellular, molecular, physiological, environmental and psychological aspects of human development, and how these processes go awry with aging, in order to best address how to repair them. Students will learn about multiple systems and techniques (including regenerative medicine). Faculty from diverse departments will come together to instruct students on the biological, psychological, social, and public policy components of the development and aging populations, as well as state of the art reparative approaches. Graduates will be well prepared to carry out innovative, interdisciplinary research to address critical challenges facing our developing and aging populations.

Public Health Implementation Science

Health Implementation Science is an emerging field strongly endorsed by the National Institutes of Health, The Institute of Medicine, and The National Research Council. It is located at far end of the clinical translational continuum -- focused on scientific inquiry about the "uptake" of major medical and health discoveries by practitioners and policymakers and their impact on the well-being of individuals and communities. Historically, the lag time from discovery of a major efficacious treatment to its actual clinical implementation has been estimated as 17 years, and many highly efficacious, affordable treatments are being implemented improperly, incompletely, and/or inequitably, thus failing to realize the benefits anticipated. Above all, there is grave concern that the mega-investments in basic science and clinical research are not yielding their full impact. In a now-seminal New England Journal of Medicine article, Zerhouni (2005), then Director of the National Institutes of Health, called for corrective action by creating "a new, vital, and reinforced academic discipline and home for translational and clinical science — along with an explicit effort to maximize the effectiveness of NIH resources directed to this area of research — to ensure that extraordinary scientific advances of the past decade will be rapidly captured, translated, and disseminated for the benefit of all Americans." Students in the Health Implementation Science focus area will learn the basic terminology and approaches from a range of specialty fields -- including health literacy, information dissemination, health systems research, public health, community-based participatory research, health economics, and health disparities research – and explicitly connect them to conduct implementation science. Students will engage in case studies from all of the major basic biology, medicine, and health fields to understand the pathway from discovery of efficacious treatments or preventive interventions to their extension to clinical practice and the measurement of patient-oriented outcomes.

Immunity and Infectious Disease

Students entering this focus area will have an interest in performing research towards the understanding, prevention, and treatment of infectious and immunologic diseases. Track-specific coursework will take an integrative, translational approach to all aspects of infectious disease. They will learn about and discuss contemporary and emerging pathogens (viral, bacterial, and other), the human immune response, the development and delivery of novel diagnostics and therapeutics, as well as the social, psychological, and economic consequences of infectious and immune diseases. Students will develop a professional level of expertise in immunity and infectious disease, and learn to apply this knowledge to carry out innovative and interdisciplinary research to advance disease prevention, diagnostics and treatment.

Metabolic and Cardiovascular Science

Students entering this focus area will have an interest in improving health and quality of life through research on cardiovascular and metabolic health. Students will develop a comprehensive understanding of metabolic and cardiovascular physiology, and their interrelationship. This will include topics such as principle energy systems, appetite and energy expenditure, and cardiovascular function and regulation. Similar to other focus areas in the program, they will perform extensive analysis of primary literature and case studies covering the epidemiology, pathophysiology, and socioeconomic impact of cardiometabolic diseases (such as diabetes, obesity, and heart disease) with an emphasis on the translation of basic scientific discoveries into practical applications.

Neuroscience

Students entering this focus area will have an interest in reducing the burden of neurological and mental health disorders through research. Students will develop an understanding of the normal biological processes that undergird healthy brain and cognitive function, the causes and mechanisms of dysregulation that lead to dysfunction, and current and evolving approaches to therapy and novel therapeutic development. They will explore the inter-relationships of these processes at multiple levels at the intersection of brain biology, behavior, cognition, medicine and health and develop a strong foundation for pursuing doctoral level research in the brain and cognitive sciences.

GRADUATE COURSES (TBMH)

TBMH 5004:

Translational Biology, Medicine and Health

Processes underlying human health and disease and the context in which they occur. Normal vs. pathological lifespan trajectory of humans and animal models at the molecular, cellular, organ system, organismal, group and social levels. Homeostatic processes throughout lifes stages and the genetic, environmental, behavioral and social drivers and

interactions that lead to pathological outcomes. Pre: Graduate standing.

Credit Hour(s): 8

Lecture Hour(s): 8

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

TBMH 5014:

Fundamentals in Molecular Brain Science

Fundamental and translational neuroscience across multiple levels of analysis including molecular, cellular, systems, and developmental neurobiology, as it relates to brain function in both normal and pathologic states. Impact of brain disease burden on individuals, families and society will be discussed.

Credit Hour(s): 4

Lecture Hour(s): 4

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): TBMH 5004

Corequisite(s):

TBMH 5024:

Fundamentals of Cancer

Comprehensive survey of neoplastic diseases across scales: genetic, molecular, cellular, tissue, organism, society. Causes diagnosis and treatment of cancer. Social and economic aspects of cancer.

Credit Hour(s): 4

Lecture Hour(s): 4

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): TBMH 5004

Corequisite(s):

TBMH 5034:

Fundamentals of Health Implementation Science

Analysis of research and strategies for translating major medical and health discoveries into effective treatment delivery with measurable outcomes at the individual, health systems, and population levels. Theories of health implementation, research design and methodology, health messaging, human behavior change, health care decision making, health literacy and disparities, community-based participatory research, patient-centered research, and health economics and policy. Research new approaches to improve health outcomes, health care quality, and costs related to recent therapeutic or preventative discoveries.

Credit Hour(s): 4

Lecture Hour(s): 4

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): TBMH 5004

Corequisite(s):

TBMH 5044:

Fundamentals of Cardiovascular Science

Comprehensive survey of cardiac and vascular physiology, and their interrelationship. Epidemiology, pathophysiology, and socioeconomic impact of cardiometabolic diseases, with an emphasis on translating basic scientific discoveries into practical applications.

Credit Hour(s): 4

Lecture Hour(s): 4

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): TBMH 5004

Corequisite(s):

TBMH 5054:

Fundamentals of Immunity and Infectious Disease

Comprehensive survey of human immunity, infectious agents and disease across scales: genetic, molecular, cellular, tissue, organism, society. Diagnosis, treatment, and prevention of infectious and immune diseases. Social and economic aspects of infectious disease and immunity.

Credit Hour(s): 4

Lecture Hour(s): 4

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): TBMH 5004

Corequisite(s):

TBMH 5064:

Fundamentals of Tissue Engineering and Reparative Medicine

Comprehensive survey of pre-natal and post-natal development, aging, and repair mechanisms in different organ systems. Advances in basic research and clinical approach to developmental disorders, genetics, degenerative diseases and regenerative therapies, considered in the context of biomedical research, health care, environmental triggers, economic impact and in society at large.

Credit Hour(s): 4

Lecture Hour(s): 4

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): TBMH 5004

Corequisite(s):

Corequisite(s):

TBMH 5074:

Fundamentals of Cognitive Brain Science

Fundamental and translational neuroscience across multiple levels of analysis including cognitive, computational and systems level function, as well as individual and social cognition in normal and pathologic states. Impact of brain disease burden on individuals, families and society.

Credit Hour(s): 4

Lecture Hour(s): 4

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): TBMH 5004

Corequisite(s):

TBMH 5105:

Professional Development and Ethics

5105: Ethical standards of science and ethical issues in translational, biomedical and health research. Responsible conduct of biomedical and health research. Collaborative research strategies. Impact of translational science on national and global issues. Pre: Graduate standing. 5106: Scientific communication and grantsmanship in translational, biomedical and health research. Intellectual property, regulations, and commercialization. Career paths in biomedical and health research. Curriculum vitae and individual career development.

Credit Hour(s): 2

Lecture Hour(s): 2

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s): TBMH 5004

TBMH 5106:

Professional Development and Ethics

5105: Ethical standards of science and ethical issues in translational, biomedical and health research. Responsible conduct of biomedical and health research. Collaborative research strategies. Impact of translational science on national and global issues. Pre: Graduate standing. 5106: Scientific communication and grantsmanship in translational, biomedical and health research. Intellectual property, regulations, and commercialization. Career paths in biomedical and health research. Curriculum vitae and individual career development.

Credit Hour(s): 2

Lecture Hour(s): 2

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): TBMH 5105

TBMH 5144:

Quantitative and Translational Cardiovascular Health

Mathematical modeling, image processing, and quantitative description of transmembrane protein function and tissue-level electrophysiology. Translational and implementation science of a multi-subject human research trial involving cardiac myocytes and human electrocardiogram analysis. Quantification using statistical programming and analysis software. Professional shadowing experience. Pre: Graduate Standing.

Credit Hour(s): 4

Lecture Hour(s): 4

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

TBMH 5204:

Seminar in Translational Biology, Medicine and Health

Weekly scientific research presentations from local and invited visiting scholars on current topics related to the biomedical, translational, and health sciences. Emerging technological and methodological trends. Recent conceptual advances, their relevance across specializations, and broader societal impact. May be repeated for up to 4 credits. Pass/Fail Only. Co: 5004 on first enrollment.

Credit Hour(s): 1

Lecture Hour(s): 1

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s): TBMH 5004

TBMH 5304:

Research Experience in Translational Biology, Medicine and Health

Research experience in biomedical, translational, and health sciences. Experimental design and methods, techniques and procedures, lab safety, data analysis and significance, data presentation, evaluation of research contributions and scientific literature. May be repeated for a maximum of 15 credits. Co: 5004 Translational Biology, Medicine and Health upon first enrollment.

Credit Hour(s): 3

Lecture Hour(s):

Instruction Type(s): Lab

Instruction Type(s): Lab

Prerequisite(s):

Corequisite(s): TBMH 5004

TBMH 5404:**Scientific Logic & Analysis in Translational Biology, Medicine, and Health**

Scientific logic, hypothesis testing, study design, and evaluation of evidence in biomedical, translational, and health science research. Critical evaluation and discussion of primary research studies. Analysis of contemporary research problems and controversies, research design and methodology, and interdisciplinary scientific approaches in translational biology, medicine, and health research. Effective peer-review and its role in science.

Credit Hour(s): 1

Lecture Hour(s): 1

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s): TBMH 5004

Corequisite(s):

TBMH 5964:**Field Work/Practicum**

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

TBMH 5974:**Independent Study**

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Independent Study

Instruction Type(s): Independent Study

Prerequisite(s):

Corequisite(s):

TBMH 5984:**Special Study**

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Lecture, Online Lecture

Instruction Type(s): Lecture, Online Lecture

Prerequisite(s):

Corequisite(s):

TBMH 5994:**Research**

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Research

Instruction Type(s): Research

Prerequisite(s):

Corequisite(s):

TBMH 7994:**Research**

NONE

Credit Hour(s): 1 TO 19

Lecture Hour(s): 1 TO 19

Instruction Type(s): Research, Online Research

Instruction Type(s): Research, Online Research

Prerequisite(s):

Corequisite(s):

TRANSLATIONAL OBESITY RESEARCH

Professors: George Davis; Brenda Davy; Kevin Davy; Matthew Hulver; Dongmin Liu; Michael Madigan; Jyoti Savla; Richard Winett;

Associate Professors: Madlyn Frisard; Deborah Good; Donald McCrickard; Monica Ponder; Eva Schmelz;

Assistant Professors: Siobhan Craige; Samantha Harden; Valisa Hedrick; Benjamin Katz; Vivica Kraak; Carlin Rafie; Bin Xu;

General Contact: kdavy@vt.edu

Graduate Site: <http://interdisciplinary.graduateschool.vt.edu/tor>

Obesity is one of the most complex public health problems facing the nation and world today. More than a third of Americans and over one billion people worldwide are obese. Significant progress has been made in basic science discoveries related to the regulation of energy balance and in identifying efficacious lifestyle and pharmacologic approaches to manage obesity under tightly controlled conditions in primarily academic healthcare settings. However, there is little information available regarding the clinical relevance of many basic science discoveries or in the translation of promising clinical interventions to evidenced-based practice. Furthermore, little progress has been made in implementing and disseminating effective obesity prevention and treatment programs on a broad scale to have a positive public health impact. Thus, innovative interdisciplinary graduate training programs are needed to equip the next generation of scientists with the skills and knowledge needed to tackle the complex societal problem of obesity. This Translational Obesity Research graduate training program organized through the Interdisciplinary Graduate Education Program (IGEP) will

draw faculty and students from diverse disciplines together to form integrative research teams with a central focus on translational obesity research, spanning from "cells to society" (i.e., from basic science to practice, policy and practice implementation). Colleges and Departments: College of Agriculture and Life Science Human Nutrition, foods and Exercise Agricultural and Applied Economics College of Liberal Arts and Human Sciences Human Development Communications College of Science Psychology For more information please contact: Kevin Davy, kdavy@vt.edu, Principal Investigator

SPECIAL FACILITIES

This is an interdisciplinary program and shares facilities among departments across campus.

Facilities

Facilities are utilized based on the department of the major advisor.

DEGREES OFFERED

IGEP Degree

Offered In (Blacksburg)

TOEFL

Paper: (550.0)

iBT: (80.0)

Requirements may vary depending on department.

TRANSLATIONAL PLANT SCIENCE

Professors: Eric Beers; Glenda Gillaspay; John McDowell; Mohammad Saghai-Maroo; Birgit Scharf; David Schmale; Ann Stevens; Dorothea Tholl; Boris Vinatzer; James Westwood; Brenda Winkel;

Associate Professors: Jacob Barney; Amy Brunner; Eva Colla'kova; Jason Holliday; John Jalesko; Guillaume Pilot; Xiaofeng Wang; Bingyu Zhao;

Assistant Professors: Bastiaan Bargmann; David Haak; Song Li; Gota Morota; Susan Whitehead; Robert Wright; Bo Zhang;

John M. McDowell: johnmcd@vt.edu

TPS Web Page: translationalplantscience.org

Translational Plant Science (TPS) is the process through which knowledge from basic research on plant genetics and genomics is used to improve agricultural productivity. The central goals of the TPS program are to (1) create a new training model to prepare molecular plant scientists to function along the bench-to-marketplace pipeline; (2) catalyze interdisciplinary research to address challenges in food security, plants as biofactories, and biomass. Our program (tps.vt.edu) spans six departments and three colleges, and is designed to foster the mindsets and skills students need to link basic plant science with downstream applications, which include: a global perspective on the

challenges and opportunities presented by plant diseases; the ability to frame novel, use-inspired research questions and to pursue the answers within interdisciplinary teams; an awareness of the social and economic impacts of agricultural biotechnologies and plant disease and the ability to engage the public in meaningful dialogue about these complex issues; the ability to function effectively in the diverse cultures of the professions outside of academia that play key roles in the translational plant science pipeline (e.g. business, regulation, policy). The Graduate Program in Translational Plant Sciences allows students interested in pursuing a Ph.D. degree in this discipline to work in a wide variety of research areas ranging from plant genomics to disease resistance, metabolic engineering, bioproduction and bioprocessing, and forest biotechnology.

TPS degree candidates who enroll in the program participate in several rotations through laboratories of interest. The program of study includes selections from a range of course offerings, tailored to the background and interests of each student. At the end of the first or second semester of enrollment, a permanent advisor is selected in whose laboratory the dissertation research will be conducted. The diversity in the TPS program is evident by looking at the federal agencies that fund them: National Science Foundation, United States Department of Agriculture, Department of Energy, and National Institute of Health. Moreover, many laboratories are also supported by various Virginia and US grower organizations and industry. Colleges and Departments: College of Agriculture and Life Sciences Agricultural and Applied Economics Biochemistry Biological Systems Engineering Crop, Soil, and Environmental Science Horticulture Plant Pathology, Physiology, and Weed Science College of Science Biology College of Natural Resources and Environmental Sciences Forestry For more information please contact John McDowell, Principal Investigator, johnmcd@vt.edu

SPECIAL FACILITIES

A group of more than twenty faculty and many more students in seven departments in the Colleges of Agriculture, Science, and Natural Resources use molecular approaches to understand how plants grow and interact with their environments. We are primarily housed in Latham Hall. The William C. and Elizabeth H. Latham Agriculture and Natural Resources Building provides research and office spaces, a conference room, and a lounge for the College of Agriculture and Life Sciences and the College of Natural Resources and Environment. The building contains eight full-size growth chambers that are two stories tall and enable researchers to conduct research on life-size trees. Our researchers in seven core areas are working on finding answers to today's problems. <http://www.latham.cals.vt.edu/index.html>

Latham Hall

Many of the TPS faculty members are housed in Latham Hall. Opened in 2006, the five-floor, 85,000 sq. ft. building houses researchers from the College of Agriculture and Life Sciences, the College of Natural Resources and Environment, and the College of Science. Building equipment includes multiple reach-in growth chambers, eight walk-in growth chambers, an insectary, and resources supporting mass spectrometry and liquid chromatography. A 40-person seminar room, a conference room, and several smaller meeting rooms are available for researcher interaction and informal gatherings. John McDowell, professor of plant pathology, physiology, and weed science, is the Fralin Life Science Institute principal scientist responsible for the general oversight of the building and coordination. The Fralin institute provides

funds to seed new research initiative and for maintenance, repairs, and upgrades of common equipment.

DEGREES OFFERED

IGEP Degree

Offered In (Blacksburg)

TOEFL

Paper: (600.0)

iBT: (80.0)

GRE

General: Verbal, Quantitative, Analytical

Minimum GPA from bachelor degree: 3.0
GRE General Test required: Verbal, Quantitative, Analytical Writing/Analytical**No GRE Subject Test required
TOEFL: Paper-based 550, Computer-based 213, IBT 80, IELTS Band 7

WATER INTERFACE: INTERDISCIPLINARY RESEARCH TRANSCENDING BOUNDARIES OF ENGINEERING, SCIENCE, AND HUMAN HEALTH

Professors: Brenda Davy; Kevin Davy; Andrea Dietrich; Susan Duncan; Joseph Falkinham; Daniel Gallagher; Sean O'Keefe; Amy Pruden-Bagchi; Stephen Schoenholtz; Elena Serrano;

Associate Professors: Curtis Friedel; David Kuhn;

Assistant Professors: Valisa Hedrick; Haibo Huang; Jacob Lahne;

HNFE: Brenda Davy; Kevin Davy; Valisa Hedrick; Elena Serrano;

CEE: Andrea Dietrich; Daniel Gallagher; Amy Pruden-Bagchi;

FST: Susan Duncan; Haibo Huang; David Kuhn; Jacob Lahne; Sean O'Keefe;

BIOS: Joseph Falkinham;

Forest Resources and Environmental Conservation: Stephen Schoenholtz;

Andrea Dietrich: andread@vt.edu

David Kuhn: davekuhn@vt.edu

Graduate Site: https://www.facebook.com/waterVT?ref=aymt_homepage_panel

Graduate Site: <http://blogs.lt.vt.edu/water/>

Graduate Site: <http://interdisciplinary.graduateschool.vt.edu/water>

Water INTERface: INTERdisciplinary Research Transcending Boundaries of Engineering Science, and Human Health
WHAT? WATER is EVERYWHERE, essential for LIFE, but not always supplied in the appropriate QUALITY and QUANTITY. WHO? Collaborative interdisciplinary teams of scientists (physical, biological, health, and social) and engineers that evaluate and implement cost-effective sustainable solutions to global water challenges with integration of technology, health, safety, and public perception issues. WHY? Shortages of fresh water for drinking and agriculture are projected to

occur around the world as illustrated by this quote: "...global water consumption is doubling every 20 years, and the United Nations expects demand to outstrip supply by more than 30% come 2040" (Newsweek, October 2010). Demand for usable water necessitates taking poor quality water -waste water (industrial, agricultural, municipal) or sea water- and processing it to meet higher and/or drinking water standards. Technical solutions exist to process water of low quality water into higher quality freshwater. Yet, changes in chemical, nutrient, microbial, and sensory characteristics will influence water use, safety, consumption, health benefits, and risks. In addition, public perception and acceptance of feasible engineering solutions for solving water shortages play important roles in societal adoption of technologies. Collaborative interdisciplinary teams of scientists (physical, biological, health, and social) and engineers that evaluate and implement cost-effective sustainable solutions to global water challenges with integration of technology, health, safety, and public perception issues. WHEN? NOW. WHERE? Virginia Tech Graduate School and the Departments of Human Nutrition, Food and Exercise Food Science and Technology Civil and Environmental Engineering Biology Opportunities for Interdisciplinary Water INTERface IGEP Students include: Involvement with Water INTERface IGEP community and activities. Participation in blogging and research presentations. Possibility of partial GRA and travel funding. Earn a 9 credit Graduate Certificate in Interdisciplinary Water and Health Science: Advanced Interdisciplinary Issues and Ethics in Water Resources (GEOG 5134), Research Ethics in Agriculture and Life Sciences (ALS 5324), or Engineering Ethics and the Public (CEE 5804) (3 credits) Water for Health Seminar (GRAD 5414) (1 credit) Interdisciplinary Research (GRAD 5134) (3 credits) Independent Research Study (GRAD 5974) (2-3 credits)

SPECIAL FACILITIES

---- Water INTERface IGEP faculty and students have access to state of the art facilities are available for food processing, sensory testing, nutritional analyses, health screening, and chemical/microbial water quality analyses.

Water INTERface IGEP facilities

State of the art facilities are available for food processing, sensory testing, nutritional analyses, health screening, and chemical/microbial water quality analyses. Facilities, Equipment, and Other Resources in Civil and Environmental Engineering The Environmental and Water Resources Engineering Program at Virginia Tech maintains 20,000 ft² of laboratory space in its Durham Hall and Hancock Hall Facilities. Two full time analytical chemists are on staff to train and assist researchers. Analytical instrumentation in the Durham laboratories that are primarily used for both water and air quality analyses includes: - six Hewlett Packard gas chromatographs with a range of detection systems (including FID, ECD, N/P, and H₂) and other assemblies (autosamplers, purge and trap) - Agilent Technologies GC 6890-MSD (GC-MS) - Scientific Instrument Services Short Path Thermal Desorption Model TD-4 - three Dionex ion chromatographs; a Hewlett Packard HPLC with diode array detection; - Beckman UV/visible spectrophotometer with sipper cell - Thermo Electron X-Series inductively coupled plasma with mass spectrometer (ICP-MS) - Shimadzu LC with Diode Array, Refractive Index and Mass Spectrometer Detectors - Two field portable

Hanna multi-probes, Model HI9828, for water quality analyses - three constant temperature rooms (5 to 50 oC) - table top equipment: muffle furnaces; ultrasonicators; shaker and mixing equipment; rotary evaporators; microbalance; analytical balances - gas analyzers for carbon dioxide, carbon monoxide, nitrogen oxides, and ozone. For Water Quality Analysis, there are two (1000 ft² and 625 ft²) laboratories for setting up experiments. Routine equipment includes pH meters, conductance meters, table-top spectrophotometers (SPEC 20), balances, microscopes, extractors, glassware, autoclaves, hoods, ovens, stirrers, heaters, incubators, flowmeters, hygrometers, ISCO automatic samplers, swing psychrometers, thermohumidigraphs, personal sampling pumps. The laboratory space provides bench tops, hoods, sinks, temperature controlled rooms, walk-in refrigerators, centrifuges, and storage space necessary to perform experimental research. For Air Quality Analysis, there is 400 ft² of laboratory and computing space in Durham Hall and a shared 2500 ft² laboratory dedicated to studies of Nanoscience and Technology of the Environment in the Institute for Critical Technology and Applied Science building. Table 1 lists the laboratory's equipment for the analysis of gases and particles, and the laboratory also has numerous filter holders, diffusion denuders, primary flow calibrators, mass flow controllers, and vacuum pumps. Facilities, Equipment, and Other Resources in Food Science & Technology The Food Science and Technology program is housed in two buildings: Food Science and Technology Building (FST) and the Human and Agricultural Biosciences Building 1 (HABB1), which opened in 2014. Additional research labs are located in the Integrated Life Sciences Building (ILSB) in the Virginia Tech Corporate Research Center (CRC), the Virginia Seafood Agricultural Research and Extension Center in Hampton and the Eastern Shore Agricultural Research and Extension Center in Painter. The 93,500 square foot LEED-certified HABB1 building is designed to incorporate open workspaces and communal areas for faculty, students and industry to work collaboratively. Research areas include pilot plants, laboratories, support facilities and a sensory/flavor testing suite with camera-equipped individual sensory panel booths and conference rooms. The pilot plants feature flexible high-bay equipment areas for use in the development of scale-up operations and process/packaging engineering systems. Food Science Building (FST) Administration and faculty, staff, and grad student offices Classrooms and teaching laboratories Packaging and processing pilot plant Research laboratories Product Development and sensory evaluation laboratory Research winery and enology laboratory Analytical Services Lab High hydrostatic pressure processing laboratory Human and Agricultural Biosciences Building 1 (HABB1) Faculty, staff, and graduate offices Conference, team meeting, and seminar rooms Research laboratories Sensory evaluation suite Food processing and packaging pilot plant Food safety pilot plant (BSL2) Facilities, Equipment, and Other Resources in Human Nutrition, Foods and

Exercise HNFE occupies space in Wallace Hall, War Memorial Hall, the Integrated Life Science Building at the Corporate Research Center, and VT Riverside in Roanoke. The Laboratory for Eating Behaviors and Weight Management, the Dietary Assessment Laboratory, the Metabolic Kitchen, and the Food and Nutrition Policy Laboratory reside in Wallace Hall. The Integrated Life Sciences Building houses researchers from diverse backgrounds including, but not limited to, virology, biology, nutritional biochemistry, genetics, foods science, and behavioral science. The Molecular Nutrition, Muscle Function, and Muscle Metabolism laboratories can be found here as well as groups working on the molecular aspects of health, nutrition, and disease, including genetic determinants of obesity and the prevention of cancer, diabetes, and hypertension. This research is performed in laboratories equipped with modern molecular and cell biology instruments and tools for cellular and animal research. The building also houses equipment for the metabolic phenotyping core that allows for determination of body composition, whole body energy metabolism, glucose and insulin tolerance, analysis of metabolites, and more. Furthermore, core facilities for quantitative real-time PCR, cell culture, radio-labeled substrate metabolism, mitochondrial function, histology, confocal microscopy, and flow cytometry are also located in the building. The Human Integrative Physiology laboratory is located in War Memorial Hall and provides the infrastructure for clinical studies requiring measurements of cardiovascular structure and function, submaximal and maximal exercise performance, body composition (DEXA), resting and exercise energy expenditure and substrate metabolism, and collection and processing of tissue and blood samples. University Facilities Available - Resources are available through fee facilities for machine, electrical, and glass blowing. - ICTAS Nanoscale Characterization and Fabrication Laboratory for surface characterization which provides access to advanced equipment for electron microscopy, optical microscopy, and several spectroscopic techniques training for students and researchers in the use of the lab's instrumentation. This is a fee facility. - Learning Technologies Digital Media Center and Innovation Space which is a multimedia computer lab open to the students, faculty, and staff of Virginia Tech, as well as the local general public, with the mission of providing assistance through free and open access to software, hardware, and specially-trained staff. Includes access to still and video equipment, sound recording and processing, image and sound digital manipulation. - Video Conferencing Facilities- 15 video conferencing sites available on & off campus. - Conference room, office space/office equipment/computer facilities. - Student office space in former dormitory; available for office or research.

DEGREES OFFERED

IGEP Degree

TOEFL

Paper: (550.0)

iBT: (80.0)

GRE

Each Water INTERface graduate student must meet the requirements of their home academic department in addition to the overall Water INTERface requirements. It is also expected that students will be participate in Water INTERface IGEP community events/activities, write blogs, and conduct research presentations. A nine credit Graduate Certificate in Interdisciplinary Water and Health Science requires the following four courses: Ethics course (complete one of the following): Advanced Interdisciplinary Issues and Ethics in Water Resources (GEOG 5134) (3 credits) Research Ethics in Agriculture and Life Sciences (ALS 5324) (3 credits) Engineering Ethics and the Public (CEE 5804) (3 credits) Interdisciplinary Research (GRAD 5134) (3 credits) Water for Health Seminar (GRAD 5414) (1 credit) Independent Research Study (GRAD 5974) (2 credits)



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Africana Studies AFSC

Address:
562 McBryde Hall (0137) Virginia Tech
Blacksburg, VA 24061

Contact this Certificate

Email Contact(s):
• Onwubiko Agozino

Web Resource(s):
• Website

Phone Number(s):

[Certificate Overview](#)[Admissions & Course Requirements](#)

Graduate Certificate in Africana Studies

A graduate certificate in Africana Studies serves two populations: graduate students in other programs at Virginia Tech who would like to demonstrate additional competence in some aspect of Africana Studies, and non-degree seeking students who desire special competence in Africana Studies for personal development/career advancement. Graduate students in Higher Education and Student Affairs (HESA) and the Center for Public Administration and Policy (CPAP) can use this certificate as a cognate within their degree programs.

How to Apply:

Fill out the online application for participation in the certificate program.



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Africana Studies AFSC

Address:
562 McBryde Hall (0137) Virginia Tech
Blacksburg, VA 24061

Contact this Certificate

Email Contact(s):
• Onwubiko Agozino

Web Resource(s):
• Website

Phone Number(s):

[Certificate Overview](#)[Admissions & Course Requirements](#)

Admission Requirements

Graduate students accepted in any graduate program at Virginia Tech may be admitted to the Africana Studies certificate program. Decisions for admission to the certificate program for non-degree seeking students are made by the Sociology Graduate Admissions Committee, based on transcripts, a writing sample, and a statement of purpose.

Course Requirements

Students are required to take and pass four of the five Africana Studies graduate courses with a B average. (12 hours).

The current courses are as follows:

- AFST 5224 Africana Studies Professional Seminar
- AFST 5234 Research Methods in Africana Studies
- AFST 5314 Theories in Africana Studies
- AFST 5354 Topics in Africana Studies
- AFST 5434 History of Africana People



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Air Transportation Systems ATRC

Address:
Virginia Tech Civil & Environmental Engineering 750 Drillfield Dr. 200 Patton Hall,
MC: 0105
Blacksburg, VA 24061

Contact this Certificate

Email Contact(s):
• Blacksburg: Sarah H. Martin

Web Resource(s):
• Website

Phone Number(s):
• Blacksburg Campus:
540/231-6069

[Certificate Overview](#)

[Admissions & Course Requirements](#)

Air Transportation Systems - Certificate Overview

The Charles E. Via, Jr. Department of Civil and Environmental Engineering (CEE) coordinates the administration of seven graduate certificates. In the field of Advanced Transportation Systems, three certificates are available: Air Transportation Systems, Traffic Control and Operations, Transportation Systems Engineering. Related to Environmental Engineering, three certificates are available: Treatment Process Engineering, Water Quality Management, and Urban Hydrology and Stormwater Management. The certificate in Civil Infrastructure Systems encompasses a variety of CEE disciplines with emphasis in Infrastructure Engineering.

How to Apply:
Fill out the online application for participation in the certificate program.



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Air Transportation Systems ATRC

Address:
Virginia Tech Civil & Environmental Engineering 750 Drillfield Dr. 200 Patton Hall,
MC: 0105
Blacksburg, VA 24061

Contact this Certificate

Email Contact(s):
• Blacksburg: Sarah H. Martin

Web Resource(s):
• Website

Phone Number(s):
• Blacksburg Campus:
540/231-6069

[Certificate Overview](#)[Admissions & Course Requirements](#)

Admission Requirements

The Graduate Certificate Program in CEE is open to on-campus (Blacksburg) students, full-time and part-time, who have been approved by the Virginia Tech Graduate School to take graduate coursework. Students interested in pursuing a certificate must first complete the following steps based on their current status:

Non-degree seeking VT students or individuals currently without a graduate status at VT

1. Complete the electronic Virginia Tech Graduate School "certificate seeking" application available at <https://applyto.graduateschool.vt.edu>. Applicants should apply before beginning the certificate program if they are already in a non-degree status at VT, but must apply no less than six months prior to completion of coursework. The application requires students to outline the classes they anticipate completing for the certificate (use the list of acceptable courses below). Students taking appropriate courses toward the certificate program prior to the application for certificate are not guaranteed admission to the certificate program. Applicants will be notified by letter if they are admitted into the certificate program.

2. If admitted, meet with a CEE academic advisor to confirm a final semester and coursework plan for completion of the certificate. See below for a list of contacts.

3. At the beginning of the semester for the final certificate course, students should submit the form called "Application for Degree or Certificate Conferral" through Hokie SPA. If students have taken different courses than outlined in the original application, they must complete the following form to receive approval for the changes: https://graduateschool.vt.edu/content/dam/graduateschool_vt_edu/GAAPforms/Application_Certificate.pdf

VT students already seeking a graduate degree

1. Students must complete the form called "Application for Certificate" and submit to the CEE department. The application form requires students to outline the classes they anticipate completing for the certificate. Applicants should apply before beginning the certificate program, but must apply no less than six months prior to completion of coursework. Students taking appropriate courses toward the certificate program prior to the application for certificate are not guaranteed admission to the certificate program. Applicants will be notified by letter if they are admitted into the certificate program.

2. If admitted, meet with a CEE academic advisor to confirm a final semester and coursework plan for completion of the certificate. See below for a list of contacts.

3. At the beginning of the semester for the final certificate course, students should submit the form called "Application for Degree or Certificate Conferral" through Hokie SPA. If students have taken different courses than

outlined in the original application, they must complete the following form to receive approval for the changes: https://graduateschool.vt.edu/content/dam/graduateschool_vt_edu/GAAPforms/Application_Certificate.pdf

Course Requirements

Students who wish to complete the Graduate Certificate Program in CEE must:

1. Complete 12 hours from the course requirements listed below. Note that grades for certificate courses must be a C or higher and overall certificate GPA must be 3.0 or higher. No 4000 level classes may be used as an elective course.
2. CEE students and non-degree-seeking students must complete the Application for Degree or Certificate Conferral form online in Hokie SPA by the deadline for the semester you will complete your certificate program. You will find the ADCC form under the Graduate Student Degree Menu/Application for Degree section of Hokie SPA.
3. If the outlined courses for your planned certificate have changed from the time you originally applied for the certificate program, submit a new version of the form called "Graduate Certificate Application" to the CEE Department by the third week of class in the semester you plan to finish your certificate. The link to this form can be found here: https://graduateschool.vt.edu/content/dam/graduateschool_vt_edu/GAAPforms/Application_Certificate.pdf

Limitations (All students, independent of major)

1. A graduate student may only receive one graduate certificate within the completion of the degree requirements for a graduate degree within the CEE Department.
2. No hours can be transferred from institutions other than Virginia Tech.
3. No credits below 5000 level may be used to satisfy the requirements.
4. Course substitutions for those not on the lists below without prior approval by the CEE Graduate Director are prohibited.
5. Degree-seeking students may only count 6 of the 12 credit hours from the certificate course requirements toward their degree.
6. Non-degree-seeking students in the certificate program who are later admitted to degree-seeking status may count all 12 credit hours toward both their certificate requirements and degree requirements.

Departmental Contacts

Main Blacksburg Campus contacts :

CEE Graduate Student Coordinator

Sarah H. Martin, shmartin@vt.edu, (540) 231-6069

Director of International & Graduate Education:

Lindy Cranwell, lindycra@vt.edu, (540) 231-7296

Specific Courses for Certificates in Advanced Transportation Systems

Air Transportation Systems

All students must complete CEE 5614: Analysis of Air Transportation Systems.

The remaining three courses must be selected from those listed below:

- CEE 5660: Transportation Risk, Reliability and Security
- CEE 5600: Civil Infrastructure Systems Analysis
- CEE 5620: Transportation Network Analysis
- ENGR 5014: Applied Systems Engineering
- ISE 5484: Modeling Processes in Operations Research
- An Approved Technical Elective Course



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Applied Statistics ASTC

Address:
406A Hutcheson Hall
Blacksburg, VA 24061

Contact this Certificate

Email Contact(s):

- Christina Dillon
- Cherie Nelson

Web Resource(s):

- Applied Statistics Graduate Certificate

Phone Number(s):

[Certificate Overview](#)

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Applied Statistics Graduate Certificate

The Graduate Certificate in Applied Statistics is designed to teach students the fundamental principles of statistics and the skills necessary to use statistical computer programs for data analysis. Students will learn how to choose the appropriate statistical model for a research project, prepare a data set for analysis, and use the applicable computer software program to analyze data sets. The program covers topics such as statistical inference, modeling, and computer programs (e.g. R Suite, SAS). Graduates will be prepared to use statistical methods and software programs to analyze data sets and summarize the results.

The certificate has two target audiences: 1) graduate students currently enrolled in a graduate degree program related to applied statistics (e.g., Statistics, Higher Education, Educational Leadership and Policy Studies) and 2) current data analysis professionals in organizations that gather and analyze data, such as marketing companies and nonprofit agencies.

Full-time and part-time students may enroll in the certificate program, Degree-seeking students may take courses in conjunction with their regular course load. Students attending full-time can complete the certificate in a minimum of one academic year (two semesters) and a maximum of three academic years (six semesters). Degree-seeking students attending part-time can complete the certificate in approximately two academic years (four semesters) and a maximum of four academic years (eight semesters).

Non-degree seeking, full-time students can complete the certificate in a minimum of one academic year (two semesters). Non-degree seeking, part-time students, taking one course per semester, can complete the certificate in two academic years (four semesters).

How to Apply:

Fill out the online application for participation in the certificate program.

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Applied Statistics ASTC

Address:
406A Hutcheson Hall
Blacksburg, VA 24061

Contact this Certificate

Email Contact(s):

- Christina Dillon
- Cherie Nelson

Web Resource(s):

- Applied Statistics Graduate Certificate

Phone Number(s):

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Admission

All students will be required to apply to the certificate program. The admission requirements will be based on enrollment status at the institution.

Degree-seeking students:

- Submit a Graduate Certificate Application
- Possess a bachelor's degree from an accredited institution with a GPA of 3.0 or better

Non-degree seeking students:

- Submit a Graduate School Application for admission and pay the fee
- Submit a Graduate Certificate Application and pay the fee
- Possess a bachelor's degree from an accredited institution with a GPA of 3.0 or better
- Submit official undergraduate transcripts demonstrating bachelor's degree conferral
- Undergraduate coursework and statistics in computer programming are recommended.
- Students who have not earned a degree in the United States must submit Test of English as a Foreign Language (TOEFL) minimum score of 90 on the internet-based (iBT) or the International English Language Testing System (IELTS) with a minimum score of 6.5
- TOEFL scores of 20 or greater in Listening, Writing, Speaking, and Reading subsections

Curriculum Requirements

The curriculum requires coursework to develop students' knowledge of statistical modeling (e.g., multiple linear regression, analysis of variance) and modern statistical programs (e.g., R Suite, SAS, JMP, SPSS). Students will learn about analyzing, summarizing, and interpreting the results of data analyses. Students will gain an understanding of how to prepare raw data sets for analysis and how to choose the most appropriate statistical model for a given research goal/project (e.g., hypothesis testing, interval estimation). Students will learn how to use statistical software programs to analyze a data set.

The certificate requires completion of twelve credit hours consisting of three required core courses and a fourth course selected from a choice of two restricted electives. All courses for the certificate must be graded. Students must attain a minimum GPA of 3.0 in all four courses.

Program Requirements

Total Number of Credit Hours: 12 graduate credits (Transfer credits are not permitted.)

Required Core Courses – 9 credits

- STAT 5615 – Statistics in Research I. (3H, 3C)
- STAT 5616 – Statistics in Research II. (3H, 3C)
- STAT 5054 – Introduction to Statistical Computing. (3H, 3C).

Restricted Electives – 3 credits (select one)

- STAT 5024 – Communication in Statistical Collaborations. (3H, 3C)
- STAT 5904 – Project and Report. (3H, 3C)

Course Delivery Format

The certificate program will be conducted in a hybrid format. Some courses are classroom-based, located on the Virginia Tech campuses in Blacksburg and the National Capital Region. Some courses are delivered via distance learning from Virginia Tech Blacksburg to Virginia Tech National Capital Region or vice versa. Some courses are delivered online.



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Arts Leadership ALC

Address:
344 Henderson Hall (0141) 195 Alumni Mall
Blacksburg, VA 24061

Contact this Certificate

Email Contact(s):
• Amanda Nelson

Web Resource(s):
• Program details

Phone Number(s):

[Certificate Overview](#)

[Admissions & Course Requirements](#)

Arts Leadership

The graduate certificate in Arts Leadership is designed to prepare professionals to pursue work in arts management. Students will develop specific knowledge of a variety of arts management areas, such as arts leadership and management, nonprofit financial management, arts marketing, development (fundraising), and arts advocacy.

The Arts Leadership Certificate is intended for graduate students, currently enrolled in a graduate degree program at Virginia Tech, and local professional interested in learning skills and gaining knowledge in arts management.

How to apply: Contact Dr. Amanda Nelson via email amandajnelson@vt.edu. The online application to participate in the certificate program may be found [here](#).

How to Apply:
Fill out the online application for participation in the certificate program.



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Arts Leadership ALC

Address:
344 Henderson Hall (0141) 195 Alumni Mall
Blacksburg, VA 24061

Contact this Certificate

Email Contact(s):
• Amanda Nelson

Web Resource(s):
• Program details

Phone Number(s):

[Certificate Overview](#)

[Admissions & Course Requirements](#)

Graduate Certificate in Arts Leadership

Degree-seeking applicants

For admission to a graduate degree program, the Graduate School requires:

- Completion of a bachelor's degree from an accredited institution
- GPA of 3.0 or better for the last half of the credits earned for the undergraduate degree
- Submission of official transcripts
- International applicants must submit scores from the Test of English as a Foreign Language (TOEFL) with a minimum of 550 paper-based (PBT) or 90 internet-based test (iBT), or the International English Language Testing System (IELTS) with a minimum score of 6.5

To earn a graduate certificate along with a degree:

- Students must submit a Graduate Certificate Application
- Students are classified within their degree program
- Up to 50% of the certificate credits may be used to meet degree requirements if they are appropriate for inclusion on the degree Plan of Study.

Non-degree seeking applicants

Persons who wish to enter Virginia Tech to obtain a graduate certificate without being enrolled in a degree program may apply for admission to Graduate Certificate status as follows:

- Submit an Application for Admission and a Graduate Certificate Application
- Completion of a bachelor's degree from an accredited institution
- GPA of 3.0 for the last half of the credits earned for the undergraduate degree
- Submit official transcripts
- Possess an academic background appropriate for the Certificate
- International applicants must submit scores from the Test of English as a Foreign Language (TOEFL)

with a minimum of 550 paper-based (PBT) or 90 internet-based test (iBT), or the International English Language Testing System (IELTS) with a minimum score of 6.5

Graduate Certificate in Arts Leadership Courses

Students will need to successfully complete 12 credit hours/4 courses to earn the Certificate in Arts Leadership. Students will be required to take one of the topics offered through the core course TA 5614: Topics in Arts Leadership I. Topics rotate and include arts management, arts leadership, or arts advocacy. Please refer to the timetable of classes for specific offerings each semester.

Students will also **select three electives** from those listed below which cover a range of specialized topics in arts management, including financial management for the arts, arts marketing, development (fundraising), and human resources in the arts.

Topics courses are not sequential, and students may take elective courses prior to fulfilling the core course requirement.

Course Options

TA 5614 Topics in Arts Leadership I (3credits; may be repeated for credit with different content)

Topic-centered investigation in arts management, leadership, or advocacy.

TA 5624 Topics in Arts Leadership II (3 credits; may be repeated for credit with different content)

Topic-centered investigation in specialized areas of arts management: arts marketing, development (fundraising), or grant writing.

TA 5634 Topics in Arts Leadership III (3 credits; may be repeated for credit with different content)

Topic-centered investigation in various areas of advanced arts management: human resources, financial management, or strategic management.

UAP 5574 Arts, Culture, and Society (3 credits)

Considers the role of the arts in society, including architecture, music companies, or theatre productions to heritage sites, science museums, and art galleries.



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Big Data BDC

Address:
VT-MIT Program Northern Virginia Center 7054 Haycock Road, Suite 365
Falls Church, VA 22043

Contact this Certificate

Email Contact(s):

• MIT Email

Web Resource(s):

• MIT Website

• MIT Certificates Website

Phone Number(s):

• MIT Office:

703/538-8384

[Certificate Overview](#)[Admissions & Course Requirements](#)

Graduate Certificate in Big Data

The purpose of this certificate is to provide students with a solid foundation in modern tools and technologies to succeed as a machine learning applications and deployment engineer. The emphasis is on foundational methods spanning data storage and querying, data analysis, and data visualization. Specific emphasis is also placed on social media data, one of the fastest growing segments of the big data economy. The certificate prepares students in state-of-the-art languages and pipelines for machine-learning algorithm implementation over massive datasets.

Learning Outcomes: Students who complete this certificate will be able to

- Explain how Big Data applications are built using architectures, such as Apache Hadoop, Apache Spark, NoSQL, and MongoDB.
- Use object-oriented programming to implement data processing pipelines using Python and Big Data architectures.
- Tackle practical programming issues underlying storing, retrieving, accessing, and processing large datasets.
- Implement machine learning methods and apply them to large scale datasets.
- Implement specialized pipelines for analyzing social media data, including network analysis, information extraction, and sentiment analysis.
- Apply fundamentals of data and information visualization to deliver visual insights.
- Analyze real-world datasets to develop applications.

Target Audience and Time to Complete:

The target audience is Virginia Tech graduate students who are interested in adding expertise in data management and analysis to that gained in their current degree program.

However, we also expect that a number of other professionals will pursue the certification both for job knowledge and career enhancement. Those students will be admitted as non-degree seeking, MIT-Commonwealth students. In most cases time to completion will be three semesters. Degree-seeking students may take courses in conjunction with their regular course load.

Students attending full-time can complete the certificate in a minimum of one calendar year and a maximum of four academic years. Degree-seeking students attending part-time can complete the certificate in approximately two academic years and a maximum of three academic years.

Non-degree seeking, full-time students can complete the certificate in a minimum of one calendar year (three semesters). Non-degree seeking, part-time students, taking one course per semester, can complete the certificate in two academic years (four semesters).

[Master of Information Technology \(MIT\) Program](#)

[MIT Graduate Certificates](#)

How to Apply:

Fill out the online application for participation in the certificate program.



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Big Data BDC

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VT-MIT Program Northern Virginia Center 7054 Haycock Road, Suite 365
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• MIT Email

Web Resource(s):

• MIT Website

• MIT Certificates Website

Phone Number(s):

• MIT Office:

703/538-8384

[Certificate Overview](#)[Admissions & Course Requirements](#)

Admission Requirements for the Graduate Certificate in Big Data

Admission to the Graduate School and completing a Graduate Certificate Application are required for both degree- and non-degree seeking students.

Degree-seeking applicants: The Graduate School requires completion of a bachelor's degree from an accredited institution with a GPA of 3.0 or better for admission to Certificate Status. Applicants with an undergraduate GPA < 3.0 may qualify for Commonwealth Campus admission. Students pursuing a degree and a certificate simultaneously are classified within their degree program.

For students interested in pursuing both the Master's degree in MIT and the certificate in Information Technology Management no more than fifty percent of certificate courses will be included toward completion of the MIT degree.

Non-degree seeking applicants: A qualified person who wishes to enter Virginia Tech to obtain a graduate certificate, without being enrolled in a degree program, may apply for graduate admission to Graduate Certificate by completing the [certificate application](#).

Applicants must meet the following criteria:

- GPA of 3.0 for admission for the last half of the credits earned for the undergraduate (bachelors) degree*
- Official transcripts must be submitted
- Academic background meets the requirements of the admitting academic unit
- International Applicants must submit scores from the Test of English as a Foreign Language (TOEFL) or International English Language Testing System (IELTS). A minimum TOEFL score of 550 paper-based (PBT) or 80 internet-based test (iBT) is required for consideration of the application. On the iBT, sub-scores of at least 20 on each subject test (Listening, Speaking, Reading, and Writing) are required for admission. A minimum IELTS score of 6.5 is required for admission. Some departments have higher TOEFL or IELTS score requirements than those set by the Graduate School.

[Admissions - MIT Graduate Certificates](#)

Course Requirements for the Graduate Certificate in Big Data

Number of Credit Hours:

A total of nine credit hours are required. Transfer credits are not permitted. Students must maintain a minimum GPA of 3.0 in the designated courses.

Required Courses:

CS 5044 Object-Oriented Programming with Java: Object-oriented programming concepts and the Java programming language. The application of design strategies, notations, and patterns related to object-oriented systems. Techniques and libraries for developing applications related to the World Wide Web. (3H, 3C)

CS 5644 Machine Learning with Big Data: Basic principles and techniques for big data analytics, including methods for storing, searching, retrieving, and processing large datasets; introduction to basic machine learning libraries for analyzing large datasets; data visualization; case studies, with real-world datasets. Pre: 5044. (3H, 3C)

CS 5664 Social Media Analytics: Social media platforms, media feeds, and data formats; machine learning and graph theory foundations of social media analytics; Forms of social media analytics – text analytics, network analytics, and action analytics; Forecasting models and applications, including in marketing, event tracking, surveying, and A/B testing. Pre: 5644. (3H, 3C)



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Biobased Materials BBMC

Address:
230 Cheatham Hall
Blacksburg, VA 24061

Contact this Certificate

Email Contact(s):
• Maren Roman

Web Resource(s):
• Website

Phone Number(s):
• Phone::
540/231-1421

[Certificate Overview](#)

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Certificate Overview

This certificate is offered by the [Bio-based Materials Center](#). Information on how to apply for the certificate can be found [here](#).

How to Apply:
Fill out the online application for participation in the certificate program.



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Biobased Materials BBMC

Address:
230 Cheatham Hall
Blacksburg, VA 24061

Contact this Certificate

Email Contact(s):
• Maren Roman

Web Resource(s):
• Website

Phone Number(s):
• Phone:
540/231-1421

[Certificate Overview](#)[Admissions & Course Requirements](#)

Admission Requirements

Admission into the program for the Certificate in Biobased Materials requires:

- a bachelor's degree in a scientific or engineering discipline
- enrollment at the graduate level at Virginia Tech as
 - a degree seeking student,
 - a non-degree seeking student, or
 - a Commonwealth Campus student
- good academic standing (for currently enrolled Virginia Tech students)
- submission of a completed application form

Please note that the graduate school will not grant the certificate unless at least one of the courses has been taken in or after the 2011 Spring Semester (i.e., after approval of the certificate program).

Course Requirements

The certificate requires completion of a minimum of nine credit hours from the following list of courses. Students must attain a minimum GPA of 3.0 in the courses counting towards the Certificate. Related Virginia Tech courses not included in the list may be substituted. Course substitution requests must be approved by the certificate faculty in the Department of Wood Science and Forest Products.

BCHM 5124 – Biochemistry for the Life Sciences

Basic principles of biochemistry including protein structure, enzymology, gene expression, bioenergetics, and pathways of energy metabolism. Not available to Biochemistry majors. I. (3H, 3C)

BCHM 5224 – Protein Structure and Function

Structure and function of proteins. Topics include special techniques in protein purification and characterization, techniques for studying protein structure, posttranslational modification of proteins and selected topics to study the structure-function relationship of proteins. Taught alternate years. I. (3H, 3C)

BCHM 5304 – Enzyme Kinetics and Reaction Mechanisms

Analysis of the mechanisms of enzyme-catalyzed reactions using kinetic and spectroscopic measurements, inhibitors and other chemical probes, or enzyme modification via sitedirected mutagenesis. Development and interpretation of kinetic rate equations. Theory and models of enzymatic catalysis. II. Alternate years. (3H, 3C)

BSE 5504G – Advanced Bioprocess Engineering

Study of the engineering concepts for biological conversion of raw materials to food, pharmaceuticals, fuels, and chemicals. Emphasis is placed on enzyme kinetics and technology, bioreaction kinetics, analysis, and control of bioreactors and fermenters, and downstream processing of bioreaction products. II. (3H, 3C)

BSE 5544G (CHE 5544G) – Advanced Protein Separation Engineering

Concepts, principles and applications of various unit operations used in protein separations. Properties of biological materials, such as cells and proteins, and their influences on process design. Design of processes for protein purification based on the impurities to be eliminated. Concepts and principles of scale-up of unit operations. Case studies in practical protein recovery and purification issues, with a focus on enhanced protein purification by genetic engineering. Protein purification process simulation and optimization using process simulation software. (3H, 3C)

BSE 5644 – Biobased Industrial Polymers

Importance of renewable feedstocks (i.e., proteins, polysaccharides, and fats) to industrial polymers and the future economy. Chemistry and processing of plant- and animal-based feedstocks into polymers. Properties of renewable materials. (3H, 3C)

BSE 5624 – Enzyme Engineering

Introduction to enzymatic biocatalysis. Enzyme kinetics on solid and soluble substrates. Directed enzyme evolution vs. rational enzyme design. Cell-free synthetic enzymatic pathway engineering. (3H, 3C)

CHE 5214 (BMES 5434) – Polymeric Biomaterials

This is an interdisciplinary course intended for graduate students. The major objective of this course is to introduce principles and concepts critical to the successful design of polymerbased biomaterials, drug-delivery devices, and bio-implants. The course will be broken down into the following four areas, polymer design and processing, inflammatory responses to polymers, interaction of blood with polymeric materials, and the effect of mechanical, chemical, and surface properties of polymers on cells. Students will be expected to know undergraduate engineering, polymers, and, biology. (3H, 3C)

WOOD 5424 (CHEM 5424) – Polysaccharide Chemistry

Structure, properties, and applications of natural polysaccharides. Natural sources and methods of isolation. Synthetic chemistry and important polysaccharide derivatives. Relation of structure and properties to performance in critical applications including pharmaceuticals, coatings, plastics, rheology control, and films. Conversion by chemical and biochemical methods of polysaccharide biomass to fuels and materials. Graduate standing required. (3H, 3C)

MACR 5015 or* 5016 – Macromolecular Fundamentals Laboratory I and II

The course will cover fundamentals and experimental techniques for the synthesis and characterization of polymeric materials. MACR 5015 includes statistical experimental design, step-growth and chain-growth polymerization, natural polymers, molecular modeling, thermal properties of polymers, molecular weight analysis, morphology, and melt and solution rheology. MACR 5016 includes static and dynamic mechanical analysis, rubber elasticity, spectroscopy, surface analysis, fracture behavior, and basic polymer processing. Must meet pre-requisites or equivalent. (2H, 1L, 3C)

*only one of the two courses, either MACR 5015 or MACR 5016, may be applied toward the certificate



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Business Data Analytics BDAC

Address:
VT-MIT Program Northern Virginia Center 7054 Haycock Road, Suite 365
Falls Church, VA 22043

Contact this Certificate

Email Contact(s):

- MIT Email

Web Resource(s):

- MIT Website
- MIT Certificates Website

Phone Number(s):

- MIT Office:
703/538-8384

[Certificate Overview](#)

[Admissions & Course Requirements](#)

Graduate Certificate in Business Data Analytics

Jobs for business intelligence analysts—employees tasked with studying and analyzing large amounts of data generated by businesses—are opening up faster than they can be filled. Corporate executives are overwhelmed with volumes of data needing analysis and summary for better decision making. Forbes listed the business intelligence analyst among its top 10 best-paying science, technology, engineering and mathematics (STEM) jobs last year. While some industries have a greater need for this role than others, the position is by no means industry-specific—it can be found in a wide variety of settings. In the business intelligence and analytics module students (1) learn core intranets: electronic data interchange, electronic banking and payment systems, security and firewalls, software agents, and the social, legal, and international issues of electronic commerce; (2) review business intelligence and analytics technologies; (3) define and frame the business context for decisions, decision models, data issues, business intelligence, building analytics capability, cloud computing, making organizations smarter, and measuring the value of analytics; and (4) study analytics software and techniques: data preparation, data exploration and visualization, predictive analytics techniques, text analytics, and spatial analytics.

In today's business environment, ad-hoc approaches to information systems development are not sufficient. Modern approaches to the development of information systems, such as structured systems development, relational database development, and object-oriented systems development, are required. The Business Information Systems module prepares the student to become a business information systems developer using both structured and object-oriented systems development approaches. It also prepares the student to be able to design and develop business information systems that use a relational database. In this module, the student studies the strategies and techniques for dealing with the inherent complexity in the development of information systems. System development topics include coverage of (1) business systems planning; (2) fact-finding and requirements analysis techniques; (3) information systems process modeling; (4) logical and physical design; (4) user interface design; (5) introduction to database management systems and their use in business. Database topics covered include (1) data modeling, (2) normalization, (3) SQL, (4) transaction management and concurrency control, (5) physical data organization, (6) query optimization, (7) database administration, (8) distributed databases, (9) data warehousing, (10) integrating databases with the web.

One of the core problems in the broad arena of Information Technology is the extraction of useful information from massive amounts for data that is collected and stored. Two closely related disciplines lie at the head of the problem. The first is the construction of efficient, logically organized databases that reflect the physical and organizational realities that comprise the problem domain; and the second is the extraction of useful business intelligence from those databases.

This set of three courses in the certification in Business Data Analytics will provide students with the specialized knowledge required to attack this problem domain.

Target Audience and Time to Complete:

The target audience is Virginia Tech graduate students who are interested in adding expertise in business data analytics to that gained in their current degree program.

However, we also expect that a number of other professionals will pursue the certification both for job knowledge and career enhancement. Those students will be admitted as non-degree seeking, MIT-Commonwealth students.

In most cases time to completion will be two semesters. Degree-seeking students may take courses in conjunction with their regular course load. Students attending full-time can complete

the certificate in a minimum of one academic year and a maximum of four academic years. Degree-seeking students attending part-time can complete the certificate in approximately two academic years

and a maximum of three academic years.

Non-degree seeking, full-time students can complete the certificate in a minimum of one academic year (two semesters). Non-degree seeking, part-time students, taking one course per semester, can complete the certificate in two academic years (four semesters).

[Master of Information Technology \(MIT\) Program](#)

[MIT Graduate Certificates](#)

How to Apply:

Fill out the online application for participation in the certificate program.



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Business Data Analytics BDAC

Address:
VT-MIT Program Northern Virginia Center 7054 Haycock Road, Suite 365
Falls Church, VA 22043

Contact this Certificate

Email Contact(s):
• MIT Email

Web Resource(s):
• MIT Website
• MIT Certificates Website

Phone Number(s):
• MIT Office:
703/538-8384

[Certificate Overview](#)[Admissions & Course Requirements](#)

Admissions Requirements for the Graduate Certificate in Business Data Analytics

Admission to the Graduate School and completing a Graduate Certificate Application are required for both degree- and non-degree seeking students.

Degree-seeking applicants: The Graduate School requires completion of a bachelor's degree from an accredited institution with a GPA of 3.0 or better for admission to Certificate Status. Applicants with an undergraduate GPA < 3.0 may qualify for Commonwealth Campus admission. Students pursuing a degree and a certificate simultaneously are classified within their degree program.

For students interested in pursuing both the Master's degree in MIT and the certificate in Information Technology Management no more than fifty percent of certificate courses will be included toward completion of the MIT degree.

Non-degree seeking applicants: A qualified person who wishes to enter Virginia Tech to obtain a graduate certificate, without being enrolled in a degree program, may apply for graduate admission to Graduate Certificate by completing the [certificate application](#).

Applicants must meet the following criteria:

- GPA of 3.0 for admission for the last half of the credits earned for the undergraduate (bachelors) degree*
- Official transcripts must be submitted
- Academic background meets the requirements of the admitting academic unit
- International Applicants must submit scores from the Test of English as a Foreign Language (TOEFL) or International English Language Testing System (IELTS). A minimum TOEFL score of 550 paper-based (PBT) or 80 internet-based test (iBT) is required for consideration of the application. On the iBT, sub-scores of at least 20 on each subject test (Listening, Speaking, Reading, and Writing) are required for admission. A minimum IELTS score of 6.5 is required for admission. Some departments have higher TOEFL or IELTS score requirements than those set by the Graduate School.

[Admissions - MIT Graduate Certificates](#)

Course Requirements for the Graduate Certificate in Business Data Analytics

Number of Credit Hours:

A total of nine credit hours are required. Transfer credits are not permitted. Students must maintain a minimum GPA of 3.0 in the designated courses.

Required Courses:

BIT 5524 Introduction to Business Intelligence & Analytics: Overview of business intelligence and analytics technologies and their strategic use including defining/framing the business context for decisions, decision models, data issues, business intelligence, building analytics capability, cloud computing, making organizations smarter, and measuring the value of analytics.

BIT 5534 Applied Business Intelligence and Analytics: Development of business intelligence and analytics solutions and applications to various types of decision-making problems. Analytics software preparation, data exploration and visualization, predictive analytics techniques, and text analytics, spatial analytics. Pre: BIT 5524

ACIS 5524 Advanced Database Management Systems: Relates database theories and practices to concepts from other areas such as programming languages, algorithms, data structures, and information systems. The relational, network, and hierarchical models are introduced. A major portion of the course deals with data

manipulation languages for the relational model, design theory for relational databases, and query optimization. Pre:
ACIS 5504



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Civil Infrastructure Systems IEC

Address:
Virginia Tech Civil & Environmental Engineering 750 Drillfield Dr. 200 Patton Hall,
MC: 0105
Blacksburg, VA 24061

Contact this Certificate

Email Contact(s):
• Blacksburg: Sarah H. Martin

Web Resource(s):
• Website

Phone Number(s):
• Blacksburg Campus:
540/231-6069

[Certificate Overview](#)

[Admissions & Course Requirements](#)

Civil Infrastructure Systems - Certificate Overview

The Charles E. Via, Jr. Department of Civil and Environmental Engineering (CEE) coordinates the administration of seven graduate certificates. In the field of Advanced Transportation Systems, three certificates are available: Air Transportation Systems, Traffic Control and Operations, Transportation Systems Engineering. Related to Environmental Engineering, three certificates are available: Treatment Process Engineering, Water Quality Management, and Urban Hydrology and Stormwater Management. The certificate in Civil Infrastructure Systems encompasses a variety of CEE disciplines with emphasis in Infrastructure Engineering.

How to Apply:
Fill out the online application for participation in the certificate program.



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Civil Infrastructure Systems IEC

Address:
Virginia Tech Civil & Environmental Engineering 750 Drillfield Dr. 200 Patton Hall,
MC: 0105
Blacksburg, VA 24061

Contact this Certificate

Email Contact(s):
• Blacksburg: Sarah H. Martin

Web Resource(s):
• Website

Phone Number(s):
• Blacksburg Campus:
540/231-6069

Certificate Overview

Admissions & Course Requirements

Admission Requirements

The Graduate Certificate Program in CEE is open to on-campus (Blacksburg) students, full-time and part-time, who have been approved by the Virginia Tech Graduate School to take graduate coursework. Students interested in pursuing a certificate must first complete the following steps based on their current status:

Non-degree seeking VT students or individuals currently without a graduate status at VT

1. Complete the electronic Virginia Tech Graduate School "certificate seeking" application available at <https://applyto.graduateschool.vt.edu>. Applicants should apply before beginning the certificate program if they are already in a non-degree status at VT, but must apply no less than six months prior to completion of coursework. The application requires students to outline the classes they anticipate completing for the certificate (use the list of acceptable courses below). Students taking appropriate courses toward the certificate program prior to the application for certificate are not guaranteed admission to the certificate program. Applicants will be notified by letter if they are admitted into the certificate program.

2. If admitted, meet with a CEE academic advisor to confirm a final semester and coursework plan for completion of the certificate. See below for a list of contacts.

3. At the beginning of the semester for the final certificate course, students should submit the form called "Application for Degree or Certificate Conferral" through Hokie SPA. If students have taken different courses than outlined in the original application, they must complete the following form to receive approval for the changes: https://graduateschool.vt.edu/content/dam/graduateschool_vt_edu/GAAPforms/Application_Certificate.pdf

VT students already seeking a graduate degree

1. Students must complete the form called "Application for Certificate" and submit to the CEE department. The application form requires students to outline the classes they anticipate completing for the certificate. Applicants should apply before beginning the certificate program, but must apply no less than six months prior to completion of coursework. Students taking appropriate courses toward the certificate program prior to the application for certificate are not guaranteed admission to the certificate program. Applicants will be notified by letter if they are admitted into the certificate program.

2. If admitted, meet with a CEE academic advisor to confirm a final semester and coursework plan for completion of the certificate. See below for a list of contacts.

3. At the beginning of the semester for the final certificate course, students should submit the form called "Application for Degree or Certificate Conferral" through Hokie SPA. If students have taken different courses than

outlined in the original application, they must complete the following form to receive approval for the changes: https://graduateschool.vt.edu/content/dam/graduateschool_vt_edu/GAAPforms/Application_Certificate.pdf

Course Requirements

Students who wish to complete the Graduate Certificate Program in CEE must:

1. Complete 12 hours from the course requirements listed below. Note that grades for certificate courses must be a C or higher and overall certificate GPA must be 3.0 or higher. No 4000 level classes may be used as an elective course.
2. CEE students and non-degree-seeking students must complete the Application for Degree or Certificate Conferral form online in Hokie SPA by the deadline for the semester you will complete your certificate program. You will find the ADCC form under the Graduate Student Degree Menu/Application for Degree section of Hokie SPA.
3. If the outlined courses for your planned certificate have changed from the time you originally applied for the certificate program, submit a new version of the form called "Graduate Certificate Application" to the CEE Department by the third week of class in the semester you plan to finish your certificate. The link to this form can be found here: https://graduateschool.vt.edu/content/dam/graduateschool_vt_edu/GAAPforms/Application_Certificate.pdf

Limitations (All students, independent of major)

1. A graduate student may only receive one graduate certificate within the completion of the degree requirements for a graduate degree within the CEE Department.
2. No hours can be transferred from institutions other than Virginia Tech.
3. No credits below 5000 level may be used to satisfy the requirements.
4. Course substitutions for those not on the lists below without prior approval by the CEE Graduate Director are prohibited.
5. Degree-seeking students may only count 6 of the 12 credit hours from the certificate course requirements toward their degree.
6. Non-degree-seeking students in the certificate program who are later admitted to degree-seeking status may count all 12 credit hours toward both their certificate requirements and degree requirements.

Departmental Contacts

Blacksburg Campus Contacts:

CEE Graduate Student Coordinator

Sarah H. Martin, shmartin@vt.edu, (540) 231-6069

Director of International & Graduate Education:

Lindy Cranwell, lindycra@vt.edu, (540) 231-7296

Specific Courses for Certificates in Civil Infrastructure Systems

Civil Infrastructure Systems

All students must complete either CEE 5600: Civil Infrastructure Systems Analysis or

CEE 5754: Pavement and Bridge Management Information Systems.

The remaining three courses must be selected from those listed below or from the course not selected from the list above:

- CEE 5010: Schedule Impact Analysis
- CEE 5084: Information Technology in Construction
- CEE 5614: Analysis of Air Transportation Systems
- CEE 5634: Analysis and Planning of Mass Transit Systems
- CEE 5080: Infrastructure Asset Management
- CEE 5014: Facility Delivery and Finance Strategies
- An Approved Technical Elective Course



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Cognition and Education CEC

Address:

Blacksburg, VA 24061

Contact this Certificate

Email Contact(s):

Web Resource(s):

• Website

Phone Number(s):

[Certificate Overview](#)

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Certificate Overview

How to Apply:

Fill out the online application for participation in the certificate program.



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Cognition and Education CEC

Address:

Blacksburg, VA 24061

Contact this Certificate

Email Contact(s):

Web Resource(s):

• Website

Phone Number(s):

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[Admissions & Course Requirements](#)

Admission Requirements

Course Requirements



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[Academic Programs](#)

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Collaborative Community Leadership CCLC

Address:
214 Litton-Reaves Hall, Mail Code: 0343
Blacksburg, VA 24061

Contact this Certificate

Email Contact(s):
• Eric Kaufman

Web Resource(s):
• Website

Phone Number(s):
• Eric Kaufman:
540/231-6258

[Certificate Overview](#)

[Admissions & Course Requirements](#)

Why this certificate?

According to national surveys, less than a third of Americans believe leaders in the United States are effective, and more than half believe the issue has become worse in the last 20 years ([Shollen & Gagnon, 2019](#)). While many express healthy skepticism of the heroic approaches to leadership ([Crosby & Bryson, 2017](#)), recent evidences suggests key opportunities in the collective dimensions of leadership ([Ospina, Foldy, Fairhurst, & Jackson, 2020](#)). In our rapidly changing world, we need leaders with interdisciplinary skills to solve complex societal issues on local, national, and international levels ([Bear & Skorton, 2019](#)). The Collaborative Community Leadership graduate certificate program will prepare participants with the educational background necessary to lead in a diverse and multi-cultural environment.

This certificate will complement Virginia Tech graduate students' academic education by preparing them with the following abilities:

- Apply knowledge of leadership principles in interdisciplinary and transdisciplinary contexts,
- Engage in scholarly inquiry as a way to critically analyze leadership theory and practice,
- Promote collaborative leadership in real-world settings, and
- Practice social responsibility in today's diverse and multicultural environment.

How to Apply:

Fill out the online application for participation in the certificate program.



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214 Litton-Reaves Hall, Mail Code: 0343
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Contact this Certificate

Email Contact(s):
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Web Resource(s):
• Website

Phone Number(s):
• *Eric Kaufman*:
540/231-6258

[Certificate Overview](#)

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Admission & Conferral

Admission to the graduate certificate program in Collaborative Community Leadership will be considered from students enrolled in any graduate program at Virginia Tech and from non-degree students who have been admitted to take courses by the Graduate School. Students who intend to pursue the certificate should complete the [Graduate Certificate Application](#). When all requirements have been satisfied, participants will submit an [application for certificate conferral](#) to have the certificate added to their academic transcript.

Curriculum

The certificate requires successful completion of 13 credit hours, including completion of a project that demonstrates application of concepts from the program. The required coursework includes two core courses and two courses from restricted electives. All courses are graduate-level and three credit hours. The project should be completed with one credit hour of independent study credit (LDRS 5974). The [website's list of possible electives](#) is not all-inclusive. Students may propose alternate options to the certificate coordinator. Common course prefixes for alternate options include COMM, GIA, PAPA, UAP, MGT, and PSYC.



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Cybersecurity Engineering CSEC

Address:
301 Whittemore Hall
Blacksburg, VA 24061

Contact this Certificate

Email Contact(s):

- Joe Tront
- Paul Plassmann

Web Resource(s):

- Website

Phone Number(s):

[Certificate Overview](#)

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Certificate Overview

The Cybersecurity Engineering (CSEC) Graduate Certificate focuses on developing advanced knowledge and skills in key areas of cybersecurity, including information security, network security, software security, and hardware security. The certificate targets both non-degree students interested in deepening their understanding, in addition to graduate students within computer science, computer engineering, and electrical engineering who seek to concentrate their coursework in cybersecurity. The certificate will be available in both Blacksburg and Northern Virginia, but there is expected to be significant growth in the Northern Virginia enrollment as part of university investment in cybersecurity.

The Cybersecurity Engineering (CSEC) Graduate Certificate seeks to help address the major cybersecurity workforce skills gap within the Commonwealth of Virginia and more broadly the Washington DC region. This certificate focuses on Virginia Tech's contribution to this ecosystem in developing deeply technical engineering and computer science skills in security. Virginia has among the densest cybersecurity workforces in the world, but also has among the highest percentage of cyber jobs unfilled. This certificate will help partially address those challenges by packaging together a range of graduate engineering and computer science courses that can be offered both as part of a graduate degree or to non-degree post-baccalaureate students.

How to Apply:

Fill out the online application for participation in the certificate program.

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Cybersecurity Engineering CSEC

Address:
301 Whittemore Hall
Blacksburg, VA 24061

Contact this Certificate

Email Contact(s):

- Joe Tront
- Paul Plassmann

Web Resource(s):

- Website

Phone Number(s):

[Certificate Overview](#)[Admissions & Course Requirements](#)

Admission Requirements

Admission to the Graduate School and completing a Graduate Certificate Application are required for all students.

The Graduate School requires completion of a bachelor's degree from an accredited institution with a GPA of 3.0 or better for admission to Certificate Status. Applicants with an undergraduate GPA < 3.0 may qualify for Commonwealth Campus admission. Students pursuing a degree and a certificate simultaneously are classified within their degree program. Certificate credits may be used to meet degree requirements if they are appropriate for inclusion on the degree Plan of Study. The faculty administering the Certificate will assist students with determining course selection.

Course Requirements

A student can earn a graduate certificate in Cybersecurity Engineering when he/she completes the following 4 courses:

Required

- CS/ECE 5560 Fundamentals of Information Security

Restricted Electives (pick 2)

- ECE/CS 5580, Cryptographic Engineering
- ECE/CS 5584, Network Security
- ECE/CS 5590, System and Software Security

Electives (pick 1)

- CS 5204, Operating Systems
- ECE/CS 5504, Computer Architecture
- ECE 5520, Secure Hardware Design
- CS/ECE 5565 Network Architecture and Protocols I
- CS 5704 Software Engineering

*A 5000- or 6000-level special topics or advanced topics course may be approved as a substitute given prior approval by the CS/ECE department.



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Cybersecurity Management CSMC

Address:
VT-MIT Program Northern Virginia Center 7054 Haycock Road, Suite 365
Falls Church, VA 22043

Contact this Certificate

Email Contact(s):

- MIT Email

Web Resource(s):

- MIT Website
- MIT Certificates Website

Phone Number(s):

- MIT Office:
703/538-8384

[Certificate Overview](#)[Admissions & Course Requirements](#)

Graduate Certificate in Cybersecurity Management

The purpose of this certificate is to provide students with a broad understanding of concepts and principles that will support management of organizations with cybersecurity concerns. The certificate will prepare students to plan, manage, and assess cyber technologies needed to secure critical corporate data and information. The emphasis will be on operational design, technology acquisition, risk assessment, and governance.

Learning Outcomes: Students who complete this certificate will be able to

- Craft corporate and business level understanding of the role of the leader in crafting corporate and business strategies where technology provides the basis for the firm's competitive advantage
- Develop an entrepreneurial plan for a technology start-up business
- Apply various business tools and strategies in managing a tech-based organization
- Examine risks posed by cyber threats to individuals, organizations, and society
- Critique prevailing national and international strategies for protecting cyberspace

Target Audience and Time to Complete:

The target audience is Virginia Tech graduate students who are interested in adding expertise in cybersecurity management to that gained in their current degree program. In addition, we also expect that a number of professionals will pursue the certificate both for job knowledge and career enhancement. Those students will be admitted as non-degree seeking certificate students.

In most cases time to completion will be two semesters. Degree-seeking students may take courses in conjunction with their regular course load. Students attending full-time can complete the certificate in a minimum of one academic year and a maximum of four academic years. Degree-seeking students attending part-time can complete the certificate in approximately two academic years and a maximum of three academic years.

Non-degree seeking, full-time students can complete the certificate in a minimum of one academic year (two semesters). Non-degree seeking, part-time students, taking one course per semester, can complete the certificate in two academic years (four semesters).

[Master of Information Technology \(MIT\) Program](#)

[MIT Graduate Certificates](#)

How to Apply:

Fill out the online application for participation in the certificate program.

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Cybersecurity Management CSMC

Address:
VT-MIT Program Northern Virginia Center 7054 Haycock Road, Suite 365
Falls Church, VA 22043

Contact this Certificate

Email Contact(s):

• MIT Email

Web Resource(s):

• MIT Website

• MIT Certificates Website

Phone Number(s):

• MIT Office:

703/538-8384

[Certificate Overview](#)[Admissions & Course Requirements](#)

Admission Requirements for the Graduate Certificate in Cybersecurity Management

Admission to the Graduate School and completing a Graduate Certificate Application are required for both degree- and non-degree seeking students.

Degree-seeking applicants: The Graduate School requires completion of a bachelor's degree from an accredited institution with a GPA of 3.0 or better for admission to Certificate Status. Applicants with an undergraduate GPA < 3.0 may qualify for Commonwealth Campus admission. Students pursuing a degree and a certificate simultaneously are classified within their degree program.

For students interested in pursuing both the Master's degree in MIT and the certificate in Information Technology Management no more than fifty percent of certificate courses will be included toward completion of the MIT degree.

Non-degree seeking applicants: A qualified person who wishes to enter Virginia Tech to obtain a graduate certificate, without being enrolled in a degree program, may apply for graduate admission to Graduate Certificate by completing the [certificate application](#).

Applicants must meet the following criteria:

- GPA of 3.0 for admission for the last half of the credits earned for the undergraduate (bachelors) degree*
- Official transcripts must be submitted
- Academic background meets the requirements of the admitting academic unit
- International Applicants must submit scores from the Test of English as a Foreign Language (TOEFL) or International English Language Testing System (IELTS). A minimum TOEFL score of 550 paper-based (PBT) or 80 internet-based test (iBT) is required for consideration of the application. On the iBT, sub-scores of at least 20 on each subject test (Listening, Speaking, Reading, and Writing) are required for admission. A minimum IELTS score of 6.5 is required for admission. Some departments have higher TOEFL or IELTS score requirements than those set by the Graduate School.

[Admissions - MIT Graduate Certificates](#)

Course Requirements for the Graduate Certificate in Cybersecurity Management

Number of Credit Hours:

A total of nine credit hours are required. Transfer credits are not permitted. Students must maintain a minimum GPA of 3.0 in the designated courses.

Required Courses:

MGT 5804 Strategic Leadership in Technology-Based Organizations: This course focuses on the role of the leader in crafting corporate and business strategies where technology provides the basis for the firm's competitive advantage.

BIT 5134 Cybersecurity Program Design and Operations: Broad coverage of the enterprise cybersecurity life-cycle. Design of a comprehensive and resilient enterprise cybersecurity program that aligns with the business objectives. Implementation and management of security operations. Security assessments and remediation of deficiencies. Security intelligence, analytics, and incident response. Measurement and communication of program effectiveness.

ACIS 5624 Cybersecurity Governance and Risk Management: Cybersecurity governance and risk management program in organizations. Governance frameworks for cybersecurity and external drivers for cybersecurity. Risk

management, including existing frameworks, principles, and strategies related to risk assessment and implementation of cybersecurity policies, controls and procedures. Budgeting and evaluation of risk management programs. Compliance with organizational cybersecurity programs, including risks of insider threats, management of security-related personnel, and establishment of cyber hygiene. Cybersecurity in relation to cybersecurity regulation.



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Cybersecurity Policy CSPC

Address:
VT-MIT Program Northern Virginia Center 7054 Haycock Road, Suite 365
Falls Church, VA 22043

Contact this Certificate

Email Contact(s):

Web Resource(s):

Phone Number(s):

[Certificate Overview](#)

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Graduate Certificate in Cybersecurity Policy

This certificate aims to provide students with a broad understanding of key factors influencing policies on cybersecurity at all levels. Cybersecurity policy is inherently trans-disciplinary, incorporating elements of technology, business, criminology, and national/international governance. The emphasis is to equip students with a strong understanding of these elements and prepare them to implement policies that improve the state and practice of cybersecurity for all stakeholders.

One need look no further than recent headlines for a plethora of examples demonstrating the need for government and industry leaders who understand how to develop, interpret, and apply cybersecurity policy. The diverse set of knowledge, skills, and abilities needed to do this successfully cannot come from a predominately technology-focused curriculum. This certificate will prepare students from a variety of backgrounds to be both tech-savvy and societally-aware in implementing policies that affect cyber security, privacy, and safety in the modern age.

Learning Outcomes: Students who complete this certificate will be able to

- Examine risks posed by cyber threats to individuals, organizations, and society.
- Critique prevailing national and international strategies for protecting cyberspace.
- Integrate legal and ethical factors in policy and technical strategies to address cyber and data threats.
- Analyze and implement legal requirements that affect the management of information, data, and defenses across multiple regulatory platforms.
- Address National Security issues from multiple public and private perspectives.
- Create technologies that meet the standards of privacy and security by design

Target Audience and Time to Complete:

The target audience is Virginia Tech graduate students who are interested in adding expertise in cybersecurity policy to that gained in their current degree program. In addition, we also expect that a number of professionals will pursue the certificate both for job knowledge and career enhancement. Those students will be admitted as non-degree seeking certificate students.

In most cases time to completion will be two semesters. Degree-seeking students may take courses in conjunction with their regular course load. Students attending full-time can complete the certificate in a minimum of one academic year and a maximum of four academic years. Degree-seeking students attending part-time can complete the certificate in approximately two academic years and a maximum of three academic years.

Non-degree seeking, full-time students can complete the certificate in a minimum of one academic year (two semesters). Non-degree seeking, part-time students, taking one course per semester, can complete the certificate in two academic years (four semesters).

[Master of Information Technology \(MIT\) Program](#)

[MIT Graduate Certificates](#)

How to Apply:
Fill out the online application for participation in the certificate program.

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Cybersecurity Policy CSPC

Address:
VT-MIT Program Northern Virginia Center 7054 Haycock Road, Suite 365
Falls Church, VA 22043

Contact this Certificate

Email Contact(s):

Web Resource(s):

Phone Number(s):

[Certificate Overview](#)[Admissions & Course Requirements](#)

Admissions Requirements for the Graduate Certificate in Cybersecurity Policy

Admission to the Graduate School and completing a Graduate Certificate Application are required for both degree- and non-degree seeking students.

Degree-seeking applicants: The Graduate School requires completion of a bachelor's degree from an accredited institution with a GPA of 3.0 or better for admission to Certificate Status. Applicants with an undergraduate GPA < 3.0 may qualify for Commonwealth Campus admission. Students pursuing a degree and a certificate simultaneously are classified within their degree program.

For students interested in pursuing both the Master's degree in MIT and the certificate in Information Technology Management no more than fifty percent of certificate courses will be included toward completion of the MIT degree.

Non-degree seeking applicants: A qualified person who wishes to enter Virginia Tech to obtain a graduate certificate, without being enrolled in a degree program, may apply for graduate admission to Graduate Certificate by completing the [certificate application](#).

Applicants must meet the following criteria:

- GPA of 3.0 for admission for the last half of the credits earned for the undergraduate (bachelors) degree*
- Official transcripts must be submitted
- Academic background meets the requirements of the admitting academic unit
- International Applicants must submit scores from the Test of English as a Foreign Language (TOEFL) or International English Language Testing System (IELTS). A minimum TOEFL score of 550 paper-based (PBT) or 80 internet-based test (iBT) is required for consideration of the application. On the iBT, sub-scores of at least 20 on each subject test (Listening, Speaking, Reading, and Writing) are required for admission. A minimum IELTS score of 6.5 is required for admission. Some departments have higher TOEFL or IELTS score requirements than those set by the Graduate School.

[Admissions - MIT Graduate Certificates](#)

Course Requirements for the Graduate Certificate in Cybersecurity Policy

Number of Credit Hours:

A total of nine credit hours are required. Transfer credits are not permitted. Students must maintain a minimum GPA of 3.0 in the designated courses.

Required Courses:

BIT 5594 Web Applications and Electronic Commerce: An examination of the concepts, technologies, and applications of electronic commerce. Topics include the World Wide Web as a platform for electronic commerce; intranets; electronic data interchange; electronic banking and payment systems; security and firewalls; software agents; and the social, legal, and international issues of electronic commerce. Must have completed the first year of the MBA program or the prerequisites to the Master of Accountancy. Pre: ACIS 5514 or BIT 5474

BIT 5114 Crime and Conflict in Cyberspace: In-depth exploration of the cyber threat landscape and the motives, methods, and mechanisms, that shape it. Complex and evolving nature of security, privacy, and safety in cyberspace. Consequences posed by cyber threats at the individual, corporate, and national, and societal levels. Cyber threat research and analysis. National and international strategies for protecting cyberspace.

BIT 5124 Cyber Law and Policy for Information Technology: Key legal, ethical, and policy cyber governance

and cyber security topics for managers and information security officers. Legal rights, remedies, and limitations related to cybercrime, computer intrusion, national security, and data breaches. Privacy laws and standards, impact assessments, privacy and security by design as policy and legal requirements. Comparison of international approaches to relevant laws and



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Cybersecurity Technologies CSTC

Address:
VT-MIT Program Northern Virginia Center 7054 Haycock Road, Suite 365
Falls Church, VA 22043

Contact this Certificate

Email Contact(s):

- MIT Email

Web Resource(s):

- MIT Website
- MIT Certificates Website

Phone Number(s):

- MIT Office:
703/538-8384

[Certificate Overview](#)[Admissions & Course Requirements](#)

Graduate Certificate in Cybersecurity Technologies

The cutting edge of IT Security extends well beyond the traditional defensive measures employed by most business and public sector entities today. And at the edge lies the collection and assessment of threat data. However, collection requires an understanding of the probable data elements that constitute a realistic threat; while assessment requires a sophisticated understanding of the systems and technologies used to collect this information.

Knowledge on Internet Security best practices, attack and defense strategies is rapidly becoming a required skill for today's Information Technology worker. There are few opportunities for students to gain hands-on experience in IT risk analysis, auditing methodologies and incident response. This class introduces students to the fundamental of computer and network security. It is a hands-on course where students learn how to analyze a client/server IT infrastructure for security weaknesses. Students also gain practical experience in analyzing common practices for security vulnerabilities that could result in the loss of sensitive company and customer information. The second course provides the advanced network security knowledge to allow students to build trustworthy systems and to protect critical infrastructures through an understanding of how to engineer and evaluate relevant security solutions. The course covers security and trust aspects of wireless mobile and ad hoc computer networks. Attack analysis and countermeasures will be studied at the transport, network, data link, and physical layers. Students will learn how to implement security and trust controls for malicious behavior prevention, detection, and recovery.

This set of three courses in the certification in Cybersecurity Technologies, will provide students with the specialized knowledge required to attack this problem domain.

Target Audience and Time to Complete:

The target audience is Virginia Tech graduate students who are interested in adding expertise in cybersecurity technologies to that gained in their current degree program. In addition, we also expect that a number of other professionals will pursue the certificate both for job knowledge and career enhancement. Those students will be admitted as non-degree seeking certificate students.

In most cases time to completion will be two semesters. Degree-seeking students may take courses in conjunction with their regular course load. Students attending full-time can complete the certificate in a minimum of one academic year and a maximum of four academic years. Degree-seeking students attending part-time can complete the certificate in approximately two academic years and a maximum of three academic years.

Non-degree seeking, full-time students can complete the certificate in a minimum of one academic year (two semesters). Non-degree seeking, part-time students, taking one course per semester, can complete the certificate in two academic years (four semesters).

[Master of Information Technology \(MIT\) Program](#)

[MIT Graduate Certificates](#)

How to Apply:

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• MIT Certificates Website

Phone Number(s):
• MIT Office:
703/538-8384

[Certificate Overview](#)[Admissions & Course Requirements](#)

Admissions Requirements for the Graduate Certificate in Cybersecurity Technologies

Admission to the Graduate School and completing a Graduate Certificate Application are required for both degree- and non-degree seeking students.

Degree-seeking applicants: The Graduate School requires completion of a bachelor's degree from an accredited institution with a GPA of 3.0 or better for admission to Certificate Status. Applicants with an undergraduate GPA < 3.0 may qualify for Commonwealth Campus admission. Students pursuing a degree and a certificate simultaneously are classified within their degree program.

For students interested in pursuing both the Master's degree in MIT and the certificate in Information Technology Management no more than fifty percent of certificate courses will be included toward completion of the MIT degree.

Non-degree seeking applicants: A qualified person who wishes to enter Virginia Tech to obtain a graduate certificate, without being enrolled in a degree program, may apply for graduate admission to Graduate Certificate by completing the [certificate application](#).

Applicants must meet the following criteria:

- GPA of 3.0 for admission for the last half of the credits earned for the undergraduate (bachelors) degree*
- Official transcripts must be submitted
- Academic background meets the requirements of the admitting academic unit
- International Applicants must submit scores from the Test of English as a Foreign Language (TOEFL) or International English Language Testing System (IELTS). A minimum TOEFL score of 550 paper-based (PBT) or 80 internet-based test (iBT) is required for consideration of the application. On the iBT, sub-scores of at least 20 on each subject test (Listening, Speaking, Reading, and Writing) are required for admission. A minimum IELTS score of 6.5 is required for admission. Some departments have higher TOEFL or IELTS score requirements than those set by the Graduate School.

[Admissions - MIT Graduate Certificates](#)

Course Requirements for the Graduate Certificate in Cybersecurity Technologies

Number of Credit Hours:

A total of nine credit hours are required. Transfer credits are not permitted. Students must maintain a minimum GPA of 3.0 in the designated courses.

Required Courses:

ECE 5484 Fundamentals of Computer Systems: Fundamental principles and concepts of computer systems. Computer hardware; Boolean logic; number systems and representation; design and operation of digital logic; analysis of instruction set architectures and computer organization; and specification of data communication and networking standards.

ECE 5585 IT Security and Trust I: Fundamental Internet and computer security principles and applications; legal and privacy issues, risk analysis, attack techniques, intrusion detection concepts, basic computer forensics, and system application hardening techniques (3H, 3C)

AND

ECE 5586 IT Security & Trust II: Advanced security and trust concepts and implementation in wired and wireless computer networks and computer systems, malware defenses, impact of channel fragility, node mobility, cooperative functionality, and resource constraints on security and trust at the different layers of the internet protocol stack. Pre: ECE 5585

OR

ECE 5480 Cybersecurity and the Internet of Things: Cybersecurity principles and technologies motivated by the evolving ecosystem of the Internet of Things (IoT): devices, operating systems, sensors, data storage, networking and communication protocols, and system services. IoT device and system security and privacy vulnerabilities, analysis and attach mitigation techniques. Pre: ECE 5484 or CS 5044



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Data Analytics DAC

Address:
3160D Torgersen Hall, Virginia Tech
Blacksburg, VA 24061

Contact this Certificate

Email Contact(s):

• Wanawsha Hawrami,
Manager of Operations for
the Discovery Analytics
Center

Web Resource(s):

• Graduate Certificate in
Data Analytics

Phone Number(s):

[Certificate Overview](#)

[Admissions & Course Requirements](#)

Graduate Certificate in Data Analytics

Description: The purpose of this certificate is to prepare students for technical careers in big data analytics and data science. Students will acquire in-depth technical skills that will enable them to understand the underlying technical fundamentals of data analytics, to develop new analytical methods, and to engineer new analytical tools. Students will acquire skills that integrate computational, statistical, and engineering techniques that form the heart of big data analytics. The certificate will provide students with formal recognition of their skills to better support their career prospects.

There is a growing need for technically trained engineers and scientists to lead the rapidly evolving field of big data analytics. The U.S. presidential administration has identified big data analytics as a core area of national need. Data science is one of the fastest growing career paths, and demand for technical expertise is out-pacing supply. Technical expertise is needed to develop new methods, tools, and infrastructures required to support novel big data analytics operations in industry, government, and academia. The technical expertise required involves a combination of computation, statistics, and engineering, such that training in any one of these individual disciplines alone does not suffice. This certificate will serve to train technical students with a broader view across these disciplines to support the data analytics field.

The learning outcomes of this certificate program are as follows:

(1) Students will have technical depth in the fundamentals of data analytics, in terms of understanding the underlying principles and implementations of analytical methods.

(2) Students will have broad understanding of multi-disciplinary perspectives on technical methods in data analytics, including computational, statistical, and engineering perspectives.

Target Audience and Time to Complete: The target audience of this certificate is technically oriented students in engineering and science. In particular, the certificate is ideally suited to complement the technical training of students enrolled in Virginia Tech's graduate programs in Computer Science, Statistics, and Electrical and Computer Engineering. Since the certificate requirements fit well with these existing degree program requirements, it is expected that the time to completion of the certificate will not substantially increase their time to completion for their degree program. Per university requirements, all 12 of the required credits for the certificate can be double counted toward a student's degree program. Students will need to take at least two additional courses beyond their existing degree requirements. However, students in other graduate programs at VT are not precluded. The estimated time to completion for students in other degree programs and for non-degree seeking participants is one year.

How to Apply:
Fill out the online application for participation in the certificate program.

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Data Analytics DAC

Address:
3160D Torgersen Hall, Virginia Tech
Blacksburg, VA 24061

Contact this Certificate

Email Contact(s):

• Wanawsha Hawrami,
Manager of Operations for
the Discovery Analytics
Center

Web Resource(s):

• Graduate Certificate in
Data Analytics

Phone Number(s):

[Certificate Overview](#)[Admissions & Course Requirements](#)

Graduate Certificate in Data Analytics

Admission:

Admission to the Graduate School and completing a Graduate Certificate Application are required for both degree- and non-degree seeking students.

Degree-seeking applicants:

The Graduate School requires completion of a bachelor's degree from an accredited institution with a GPA of 3.0 or better for admission to Certificate Status. Applicants with an undergraduate GPA < 3.0 may qualify for Commonwealth Campus admission. Students pursuing a degree and a certificate simultaneously are classified within their degree program. Certificate credits may be used to meet degree requirements if they are appropriate for inclusion on the degree Plan of Study.

Non-degree seeking applicants:

A qualified person who wishes to enter Virginia Tech to obtain a graduate certificate, without being enrolled in a degree program, may apply for graduate admission to Graduate Certificate status. Such applicants submit an Application for Admission and a Graduate Certificate Application http://graduateschool.vt.edu/content/dam/graduateschool_vt_edu/certificate_application.pdf, and must meet the following criteria:

- GPA of 3.0 for admission for the last half of the credits earned for the undergraduate (bachelors) degree*
- official transcripts must be submitted.
- academic background meets the requirements of the admitting academic unit.
- International applicants must submit scores from the Test of English as a Foreign Language (TOEFL) or the International English Language Testing System (IELTS). A minimum TOEFL score of 550 paper-based (PBT) or 80 internet-based test (iBT) is required for consideration of the application. On the iBT, subscores of at least 20 on each subtest (Listening, Speaking, Reading, and Writing) are required for admission. A minimum IELTS score of 6.5 is required for admission. Some departments have higher TOEFL or IELTS score requirements than those set by the Graduate School.

Graduate Certificate in Data Analytics

Curriculum Requirements and Descriptions

Number of Credit Hours: Students should complete at least 2 courses from the core list (see below) and 2 courses from the elective list, for a total of 12 credits. For all students, courses taken must span all three departments;

Computer Science, Statistics and Electrical and Computer Engineering. All courses must be graded A-F, and students must attain a minimum 3.0 GPA in the designated courses. Transfer credits are not permitted.

Core Courses: (Choose 2)

CS/STAT 5525 Data Analytics I

CS/STAT 5526 Data Analytics II

CS 5824/ECE 5424G: Advanced Machine Learning

Restricted Elective Courses: (Choose 2)

CS 5234 Advanced Parallel Computation

CS 5604 Information Storage and Retrieval

CS 5614 Database Management Systems

CS 5764 Information Visualization

CS 5804 Introduction to Artificial Intelligence

CS 5834 Introduction to Urban Computing

CS 5984 Deep Learning

CS 6604 Advanced Topics in Data and Information

STAT 5114 Statistical Inference

STAT 5314 Monte Carlo Methods in Statistics

STAT 5414 Time Series Analysis I

STAT 5444 Bayesian Statistics

STAT 5444G Advanced Applied Bayesian Statistics

STAT 5504 Multivariate Statistical Methods

STAT 5544 Spatial Statistics

ECE 5524 Pattern Recognition

ECE 5554 Computer Vision

ECE 5605 Signal Detection and Estimation

ECE 5734 Convex Optimization

ECE 6504 Deep Learning for Perception

ECE 6554 Advanced Computer Vision

Graduate Certificate in Data Analytics

<http://dac.cs.vt.edu/academics/data-analytics/>



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Disaster Resilience and Risk Management DRRC

Address:
1068A Derring Hall
Blacksburg, VA 24061

Contact this Certificate

Email Contact(s):
• DRRM Program

Web Resource(s):
• DRRM Webpage

Phone Number(s):

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Disaster Resilience and Risk Management Graduate Certificate

The Graduate Certificate in Disaster Resilience and Risk Management is designed to teach students the full complexity of disaster risk and resilience at the intersections of science, engineering, social science, and public policy. This certificate program helps students overcome discipline-specific conceptualizations, and generate new transdisciplinary knowledge and solutions for achieving disaster resilience. Students will learn the limitations of disciplinary approaches to managing disaster and hazards risk, as well as the advantages of and approaches for integrating frameworks, methods, and perspectives used across disciplines. Students will also learn to conduct and evaluate case studies at different geographic scales, communication and critical vocabularies for effective stakeholder engagement, and collaborative skills needed for working effectively in interdisciplinary teams.

How to Apply:

Fill out the online application for participation in the certificate program.



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Disaster Resilience and Risk Management DRRC

Address:
1068A Derring Hall
Blacksburg, VA 24061

Contact this Certificate

Email Contact(s):
• DRRM Program

Web Resource(s):
• DRRM Webpage

Phone Number(s):

[Certificate Overview](#)[Admissions & Course Requirements](#)

DRRM Admission Requirements

Degree-seeking or non-degree-seeking students will all have to apply to the certificate program.
Degree-seeking students will:

- Submit a Graduate Certificate Application
- Possess a bachelor's degree from an accredited institution with a GPA of 3.0 or better

Non-degree seeking students will:

- Submit a Graduate School Application for Admission
- Submit a Graduate Certificate Application
- Submit official transcripts
- Possess a bachelor's degree from an accredited institution with a GPA of 3.0 or better

Students who have not earned a degree in the United States must submit:

- Test of English as a Foreign Language (TOEFL) minimum score of 90 on the internet-based test (iBT) or the International English Language Testing System (IELTS) with a minimum score of 6.5
- TOEFL scores of 20 or greater in Listening, Writing, Speaking, and Reading subsections.

Program Requirements

Number of Credit Hours: **12 credit hours** of graduate level courses

Core Course – 3 credits

- GRAD 5134: Topics in Interdisciplinary Research (3 credits)

Restricted Core Cross-discipline Electives – 6 credits.

The core discipline elective requirement includes a 3 credit course focusing on the technical and engineering aspect of disasters and hazards, and a 3 credit course focusing on public policy and social science aspect of disaster and hazards.

Technical and Engineering Core Elective (3 credits). Choose one from the following list:

- BIT 5474: Computer-based Decision Support Systems (3 credits)
- CEE 5594: Geological Engineering (3 credits)
- CEE 5854G: Advanced Coastal Engineering (3 credits)
- GEOS 6204: Advanced Topics in Sedimentology, when the course topic is simulation and modeling in geosciences (3 credits)

Policy and Social Science Core Elective (3 credits). Choose one from the following:

- UAP 5084: Collaborative Planning and Community Involvement (3 credits)
- UAP 5214: Topics in Natural Resources and Natural Hazards Planning, when the topic is disaster resilience and natural hazards mitigation (3 credits)
- UAP 5784: Economic Development Planning Topics, when the course topic is Community Resilience (3 credits)
- PAPA 5354: Homeland Security and Response and Recovery (3 credits)

Electives – 3 credits

Electives are intended to broaden students' understanding of disaster resilience and risk management. They can choose one technical course or one social science course from the following list or take an equivalent course approved by the DRRM faculty.

- BIT 5414: Operations Management in a Global Environment (3 credits)
- BIT 5474: Computer-based Decision Support Systems (3 credits)
- BIT 5494: International Operations and Information Technology (3 credits)
- CEE 5080: Infrastructure Asset Management (3 credits)
- CEE 5204: GIS Applications in Civil Engineering (3 credits)
- CEE 5464: Structural Dynamics & Earthquake Engineering (3 credits)
- CEE 5470: Structural Design for Seismic Load Effects (3 credits)
- CEE 5584: Geotechnical Aspects of Earthquake Engineering (3 credits)
- CEE 5594: Geological Engineering (3 credits)
- CEE 5660: Transportation Risk, Reliability & Security (3 credits)
- CEE 5854G: Advanced Coastal Engineering (3 credits)
- CEE 5734: Urban Hydrology & Storm-water Management (3 credits)
- CEE 5844: Ocean and Coastal Wave Mechanics (3 credits)
- CEE 5864: Coastal and Estuarine Morphodynamics (3 credits)
- ENGE 5024: Design in Engineering Education and Practice (3 credits)
- ENGE 5714: Topics in Engineering Education Research Methods (3 credits)
- ENGE 6714: Topics in Engineering Education Research and Practice (3 credits)
- GEOS 5154: Strong-Motion Seismology & Seismic Hazard Analysis (3 credits)
- GEOS 5714G: Advanced Volcanic Processes (3 credits)
- GEOS 6204: Advanced Topics in Sedimentology, when the course topic is simulation and modeling in geosciences (3 credits)
- PAPA 5254: Homeland Security & Terrorist Threat (3 credits)
- PAPA 5354: Homeland Security and Response and Recovery (3 credits)
- UAP 5084: Collaborative Planning and Community Involvement (3 credits)
- UAP 5134G: Advanced Land Use and Environment: Planning and Policy (3 credits)
- UAP 5214: Topics in Natural Resources and Natural Hazards Planning, when the topic is disaster resilience and natural hazards mitigation (3 credits)
- UAP 5364: Non-Governmental Organizations in International Development (3 credits)
- UAP 5414: Natural Resources Planning Topics, when the course topic is urban environmental policy, planning, and management in developing and transitional countries (3 credits)
- UAP 5784: Economic Development Planning Topics, when the course topic is Community Resilience (3 credits)
- UAP 5854G: Advanced Planning of the Urban Infrastructure (3 credits)



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Economic Development ECDC

Address:
900 N Glebe Rd.
Arlington, VA 22203

Contact this Certificate

Email Contact(s):
• Margaret Cowell

Web Resource(s):
• Website

Phone Number(s):

[Certificate Overview](#)

[Admissions & Course Requirements](#)

Certificate Overview

Virginia Tech's Urban Affairs and Planning Program offers a Graduate Certificate in Economic Development. It is designed for those who are interested in acquiring a basic understanding of urban and regional economic development dynamics and the role of policy in influencing them.

Urban and regional planners need to know how they can develop their economies. The challenge for policymakers, economic developers and urban planners nowadays is to design appropriate local and regional economic development policies and programs to respond to challenges resulting from globalization, technological development, demographic changes, urban decline, sprawl, and social inequities.

How to Apply:
Fill out the online application for participation in the certificate program.



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Economic Development ECDC

Address:
900 N Glebe Rd.
Arlington, VA 22203

Contact this Certificate

Email Contact(s):
• Margaret Cowell

Web Resource(s):
• Website

Phone Number(s):

[Certificate Overview](#)[Admissions & Course Requirements](#)

Admission Requirements

Admission to the Certificate Program requires status as a graduate student in good standing at Virginia Tech, either as a current degree student or as a nondegree certificate student. A minimum undergraduate grade point average of 3.0 based on the last 60 semester hours of coursework is needed for admission to the Graduate School. Nondegree students whose undergraduate GPA was above 2.75 but below 3.00 may apply for admission under Commonwealth Campus status. Official transcripts must be submitted. Once admitted to the VT Graduate School, please fill out the following graduate certificate application form and submit it to the Graduate School:

Certificate Application:

http://graduateschool.vt.edu/content/dam/graduateschool_vt_edu/Application_Certificate.pdf

Course Requirements

The Certificate requires the completion of a minimum of 12 credit hours of graduate course work. To receive the Certificate, students must have a minimum grade point average of 3.0 for the courses taken. Students seeking the Certificate must complete at least six credit hours from among the following courses plus six credit hours in electives.

UAP 5234: Urban Economy & Public Policy

UAP 5104: Urban & Regional Development Theory

UAP 5784: Local Economic Development Planning

UAP 5774: Economic Development Studio

All credits for the Certificate must be 5000- or 6000-level courses and must be graded on an A-F basis unless they are only offered on a Pass/Fail basis. All courses must be taken from programs in Virginia Tech's School of Public and International Affairs with at least nine in Urban Affairs and Planning. The Certificate is offered at both the Alexandria and the Blacksburg campuses.



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Economic Risk and Global Inequality ERGC

Address:
1021 Prince St.
Alexandria, VA 22314

Contact this Certificate

Email Contact(s):

Web Resource(s):

Phone Number(s):

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Certificate Overview

How to Apply:

Fill out the online application for participation in the certificate program.



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Economic Risk and Global Inequality ERGC

Address:
1021 Prince St.
Alexandria, VA 22314

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Admission Requirements

Course Requirements



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Educational Research ERC

Address:
Educational Research and Evaluation, 1750 Kraft Drive, Corporate Research Center
Blacksburg, VA 24061

Contact this Certificate

Email Contact(s):

- Dr. Serge F. Hein, EDRE Program Area Leader
- Wanda McAlexander

Web Resource(s):

- EDRE Webpages (Section for EDRE Certificate)

Phone Number(s):

- Wanda McAlexander: 540/231-5106

[Certificate Overview](#)[Admissions & Course Requirements](#)

Overview of the Certificate

The **Graduate Certificate in Educational Research and Evaluation (EDRE)** is designed to recognize graduate students who have acquired methodological expertise that goes beyond the methodological skills that are obtained in introductory methodology courses. More specifically, the certificate recognizes the completion of specialized coursework in evaluation/assessment, measurement, qualitative methods, and/or statistics. The certificate is also intended for students who already hold a graduate degree but who would like to obtain a credential in research methodology that will be beneficial to their career.

Learning Outcomes

The EDRE Graduate Certificate demonstrates that a graduate student has achieved a level of proficiency in research methodology that exceeds what is possible at an introductory level.

Learning outcomes for the certificate include the following:

- Understand basic and advanced methodological concepts that are associated with evaluation/assessment, measurement, qualitative, and/or statistical research.
- Understand and effectively use a variety of methodological techniques and practices that are associated with evaluation/assessment, measurement, qualitative, and/or statistical research.
- Understand basic and advanced research design issues and effectively design an evaluation/assessment, measurement, qualitative, and/or statistical study.
- Develop an effective research proposal for evaluation/assessment, measurement, qualitative, and/or statistical research.
- Understand and effectively use a variety of data collection and data analysis methods or techniques that are associated with evaluation/assessment, measurement, qualitative, and/or statistical research.
- Develop an effective research report of evaluation/assessment, measurement, qualitative, and/or statistical research.
- Develop an effective oral and/or visual presentation of evaluation/assessment, measurement, qualitative, and/or statistical research.
- Understand and use appropriate criteria to effectively evaluate the quality of research proposals and research reports for evaluation/assessment, measurement, qualitative, and/or statistical research.

How to Apply:

Complete the online application for participation in the certificate program.

How to Apply:

Fill out the online application for participation in the certificate program.



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Educational Research ERC

Address:
Educational Research and Evaluation, 1750 Kraft Drive, Corporate Research Center
Blacksburg, VA 24061

Contact this Certificate

Email Contact(s):

- Dr. Serge F. Hein, EDRE Program Area Leader
- Wanda McAlexander

Web Resource(s):

- EDRE Webpages (Section for EDRE Certificate)

Phone Number(s):

- Wanda McAlexander: 540/231-5106

[Certificate Overview](#)[Admissions & Course Requirements](#)

Admission Requirements

Graduate students who are accepted into any other graduate program at Virginia Tech will be admitted to the EDRE Graduate Certificate program on the basis of acceptance into their home department.

A recommendation for admission of nondegree-seeking students to the EDRE Graduate Certificate program will be made by the EDRE Graduate Admissions Committee based on academic transcripts, a letter of interest, and the minimal requirements that are specified in the Graduate Catalog. Please note that these admission requirements differ from the EDRE program's degree admission requirements in that GRE scores and letters of recommendation are not required.

Upon completion of all of the EDRE Graduate Certificate requirements, a student must apply for conferral of the certificate using the *Application for Degree and Certificate Conferral* form that is available on the Graduate School website.

Course Requirements

Number of Credit Hours: The EDRE Graduate Certificate requires nine credit hours of specialized coursework in EDRE. This excludes introductory EDRE courses (i.e., EDRE 6605 (Quantitative Research Methods in Education I), EDRE 6606 (Quantitative Research Methods in Education II), EDRE 6504 (Qualitative Methods in Education Research I), EDRE 6704 (Evaluation Methods in Education Research I), and all 5000-level EDRE courses other than EDRE 5644 (Questionnaire Design and Survey Research in Education)) that are prerequisites for specialized EDRE courses. A grade of B or higher is required for each course that is completed for the certificate, and courses that are audited or graded as Pass/Fail cannot be used for the certificate. Also, transfer credit or credit for courses that have been completed outside of the EDRE program is not permitted.

Please note that EDRE 6634 (Advanced Statistics in Education - Regression) is required for all upper-level measurement and statistics courses and counts toward the certificate. The section that follows includes descriptions of the courses that can be used for the certificate and their prerequisite(s).

Recommended Combinations of Specialized EDRE Courses

Evaluation/Assessment: EDRE 5644, EDRE 6684, EDRE 6744, EDRE 6794 (Assessment in Higher Education)

Measurement: EDRE 6624, EDRE 6634, EDRE 6654, EDRE 6684, EDRE 6754, EDRE 6774

Qualitative Methods: EDRE 6524, EDRE 6784

Statistics: EDRE 6634, EDRE 6654, EDRE 6664, EDRE 6694, or a relevant Advanced Issues EDRE course

Courses That Can Be Used for the EDRE Graduate Certificate and Their Prerequisites

EDRE 5644**Questionnaire Design and Survey Research in Education (3H, 3C) (Pre: EDRE 5404)**

This course provides an overview of survey research useful to gather empirical data for non-experimental purposes in education and related settings. This project-based course focuses on questionnaire design including question formulation, sampling, data collection and analysis, and report writing.

EDRE 6524**Qualitative Methods in Education Research II (3H, 3C) (Pre: EDRE 6504)**

This course provides an advanced examination of qualitative inquiry in educational and human science research. It considers theoretical assumptions of major qualitative research traditions and provides students advanced skills in data analysis and representation. Offered fall and spring each year.

EDRE 6624**Measurement Theory in Education (3H, 3C) (Pre: EDRE 6634)**

Methods and theories of estimating and enhancing test score characteristics, particularly reliability and validity of aptitude and achievement tests. Problems associated with test construction, use, and score interpretation will be emphasized. Offered spring, yearly.

EDRE 6634**Advanced Statistics for Education (3H, 3C) (Pre: EDRE 6606)**

Multiple regression procedures for analyzing data as applied in educational settings, including curvilinear regressions, dummy variables, multicollinearity, and introduction to path analysis. Offered fall and spring, yearly.

EDRE 6654**Multivariate Statistics for Applications to Educational Problems (3H, 3C)(Pre: EDRE 6634)**

Multivariate statistical procedures presented in an applied research setting. Oriented toward the logical extension of univariate tests of significance and estimation procedures to multivariate problems. Emphasis on using existing computer software packages. Offered spring, yearly.

EDRE 6664**Applications of Structural Equations in Education (3H, 3C) (Pre: EDRE 6634)**

Applications of structural equation causal models in educational research and discussion of the methodological questions pertaining to such models. Topics include recursive and nonrecursive models, measurement errors in causal models, latent unobserved variables, and covariance structures. Offered fall and spring, yearly.

EDRE 6684**Instrument Development and Validation (3H, 3C) (Pre: EDRE 6634)**

Provides experiences in developing instruments, or tests, that are designed to measure educational and

psychological constructs, such as knowledge, skills, attitudes, and traits. Issues and practices related to construct specification, instrument design and administration, and analysis and summary of validity study data will be emphasized. Offered fall, yearly.

EDRE 6694

Hierarchical Linear Modeling (3H, 3C) (Pre: EDRE 6634)

Provides a conceptual framework of hierarchical linear modeling (HLM), some important statistical theory behind the HLM, and hands-on training for applying HLM technique through analyzing example data sets and projects. The course includes the formulation of statistical models for typical applications such as two-level organizational study, two-level growth model, and three-level growth model within contexts and prepares students to be able to use multilevel analysis to address research questions in their fields and write coherent summaries and interpretations of the results. Offered fall, yearly.

EDRE 6744

Mixed Method Research Design (3H, 3C) (Pre: EDRE 6606 and EDRE 6504)

Provides an introduction to mixed methods research design in the human and behavioral sciences. Students will design and execute a pilot study for a mixed method research project. Offered fall each year.

EDRE 6754

Advanced Item Response Theory (3H, 3C) (Pre: EDRE 6624 or EDRE 6684)

Provides students with the concepts and skills to carry out Item Response Theory (IRT) analyses using specialized software, and an introduction to research in measurement. Topics will include binary and polytomous models, item and ability parameter estimation, model fit, and scaling and equating. Offered every other year, spring.

EDRE 6774

Advanced Issues in Psychometric Research (3H, 3C) (Pre: EDRE 6624 or 6684)

Provides an in-depth examination of one or more research topics in psychometrics, or the statistical foundations of educational and psychological tests. Students will become familiar with current research, acquire specialized psychometric analysis skills, and learn how to conduct psychometric research. Topics covered may vary from term to term. May be repeated for a maximum of 12 credits. Offered irregularly, spring.

EDRE 6784

Advanced Issues in Qualitative Research (3H, 3C) (Pre: EDRE 6524)

Provides advanced treatment of important theoretical and methodological topics in the contemporary qualitative literature and in the ongoing development of qualitative methodology. Emphasis is placed on addressing both theoretical issues and issues of research praxis. Topics covered vary from term to term. Offered irregularly, spring.

EDRE 6794

Advanced Topics in Educational Research (3H, 3C) (Pre: varies)

Advanced treatment beyond standard courses in topics such as questionnaire design, survey sampling, factor analysis, and meta analysis. May be repeated with different topics for up to 6 hours of credit. Longitudinal Data Analysis has been offered each spring for a number of years.

EDRE 6794

Longitudinal Data Analysis (3H, 3C) (Pre: EDRE 6634)

EDRE 6794

Assessment in Higher Education (3H, 3C) (Pre: EDRE 6704)

Designed to provide an overview of theoretical, philosophical, practical, and policy issues appropriate to outcomes assessment methodology in higher education that are transferable to other educational and non-governmental settings. The course emphasizes understanding of assessment to enhance the educational environment and support academic quality.

Certificate Application Form

[EDRE Grad Certificate Application Form](#)

Fall 2016 and Afterward - Additional Application Materials

The EDRE program is required to assess the knowledge and skills that students gain from coursework that is completed for the EDRE Graduate Certificate. This requirement involves an additional step in the certificate application process, but several options are available. You can submit either an empirical or a non-empirical work sample as part of your application. Please note that the work sample that you submit must have been completed within the last two years and must be (a) a methodologically-oriented paper from one of the courses that you have taken for the EDRE Graduate Certificate, (b) a conference paper, or (c) a manuscript that has been submitted to an academic journal for review or that has been published.

The work sample that you submit will be evaluated by an EDRE faculty member who has relevant expertise, using the relevant criteria discussed below. Please note that a minimum score is not required for this evaluation.

Learning Outcome #1

The student will be able to understand, apply, and/or evaluate a specific research paradigm, research methodology, data collection method, or data analysis method.

The methodological portion of an empirical work sample will be evaluated using a five-point scale:

- 1) Was the research methodology used appropriate for investigating the research problem or research question(s)?
- 2) Was the research methodology understood and used correctly?

A non-empirical work sample will be evaluated using a five-point scale:

- 1) Was the research paradigm, research methodology, data collection method, or data analysis method described/explained accurately?
- 2) If relevant, was the research paradigm, research methodology, data collection method, or

data analysis method critiqued/evaluated effectively?

Learning Outcome #2

The student will be able to understand and/or apply fundamental methodological concepts that are associated with a specific research paradigm, research methodology, data collection method, or data analysis method (e.g., validity, reliability, generalizability, HLM, SEM, or IRT, as they are understood within a specific methodological tradition).

The Results, Discussion, Limitations, and Conclusion sections of an empirical work sample will be evaluated using a five-point scale:

- 1) Were the results interpreted correctly?
- 2) Were the results discussed in relation to the stated research problem or research question(s)?
- 3) Did the above sections of the work sample demonstrate an understanding of, and adherence to, the methodological requirements for validity, reliability, generalizability, and/or other fundamental methodological concepts such as those that are used in HLM, SEM, or IRT?

A non-empirical work sample will be evaluated using a five-point scale:

- 1) Were fundamental methodological concepts described/explained accurately?
- 2) If relevant, were fundamental methodological concepts critiqued/evaluated effectively?

Additional Application Requirements for Fall 2016 and Afterward



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Engineering Education ENG C

Address:
Department of Engineering Education (0218)
Blacksburg, VA 24061

Contact this Certificate

Email Contact(s):

- Jacob Grohs
- Tamara Knott

Web Resource(s):

- Website

Phone Number(s):

- *Department Receptionist:*
540/231-6555
- *Department Graduate Coordinator:*
540/231-9543

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Certificate Overview

Our Graduate Certificate in Engineering Education is popular with students from across the College of Engineering. Requiring 13 credits, the certificate is complementary to graduate study in a traditional engineering discipline and serves to brand the recipient as someone who has made the decision to learn more about education of engineering students. The certificate is also complementary to the [Future Professoriate Graduate Certificate](#) offered by the Graduate School in the sense that with careful selection of electives, students can earn both certificates at the same time.

The Certificate program is designed for graduate students in engineering and related disciplines interested in engineering education who wish to explore teaching practices specific to engineering courses.

How to Apply:

Fill out the online application for participation in the certificate program.



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Engineering Education ENGC

Address:
Department of Engineering Education (0218)
Blacksburg, VA 24061

Contact this Certificate

Email Contact(s):

- Jacob Grohs
- Tamara Knott

Web Resource(s):

- Website

Phone Number(s):

- *Department*

Receptionist:

540/231-6555

- *Department Graduate*

Coordinator:

540/231-9543

[Certificate Overview](#)[Admissions & Course Requirements](#)

Admission Requirements

Graduate students wishing to earn the graduate Certificate in Engineering Education must be currently enrolled (not provisional) masters or doctoral students in good standing in any Virginia Tech discipline or major. For admission to the Certificate program, applicants must also satisfy at least one of three requirements:

- Enrollment in a graduate program in the College of Engineering, or
- Bachelor's degree in any field of engineering, or
- Bachelor's degree in the physical or biological sciences or mathematics

Applicants who do not meet any of the three requirements may request special consideration from the ENGE Graduate Committee. The Committee will stipulate coursework that the student would need to begin studies for the Certificate and may recommend that the student be admitted on a provisional basis until the specified coursework is successfully completed. In general, the specified coursework will not count toward the credits required for the Certificate.

Please visit enge.vt.edu to download the application.

Course Requirements

Required core courses (7 credits):

- **ENGE 5014:** Foundations of Engineering Education (3 cr) Sample Syllabus
- **ENGE 5504:** Practicum in the Engineering Classroom (1 cr) Sample Syllabus
- **GRAD 5104:** Preparing the Future Professoriate (3 cr)

A minimum of three (3) credits from the Pedagogy List

- **GRAD 5114:** Pedagogical Practices in Contemporary Contexts (3 cr)
- **ENGE 5024:** Design in Engineering Education and Practice (3 cr)
- **ENGE 5204:** Design of Laboratory Courses for Engineering Education (3 cr)
- **ENGE 5404:** Assessment Techniques in Engineering Education (3 cr)

A maximum of three (3) credits from the Elective List

Recommended electives related to teaching

- **EDCI 5114:** Advanced Educational Psychology (3 cr)
- **EDCI 5164:** Principles of Instructional Design (3 cr)
- **EDCI 5604:** Distance Education (3 cr)
- **EDCI 6644:** College Teaching (3 cr)
- **GRAD 5004:** GTA Workshop (1 cr)
- **GRAD 5984:** Critically Engaged Teaching with Advanced Technology (3 cr)



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Entrepreneurship in Hospitality and Tourism Management EHTC

Address:
7054 Haycock Road
Falls Church, VA 22043

Contact this Certificate

Email Contact(s):

- Professor Mahmood Khan

Web Resource(s):

- Website

Phone Number(s):

- Mahmood Khan:
703/538-8486

[Certificate Overview](#)[Admissions & Course Requirements](#)

Entrepreneurship in Hospitality and Tourism Management Overview

Applications for the Graduate Certificate in Entrepreneurship in Hospitality and Tourism Management will be considered from students enrolled in a graduate degree program at Virginia Tech and from non-degree and Commonwealth Campus students who have undergraduate degrees. Certificates will be awarded upon application for the certificate once course requirements have been completed. The certificate has been designed so that both degree and non-degree seeking students from other majors may take the three courses within one semester and complete the certificate.

New entrepreneurs often possess innovative ideas but lack the business skills that will make them successful. Entrepreneurs differ from other business start-ups in that they are creating a unique and ground-breaking approach to a business. They have unique approaches, different business models, and/or innovative delivery techniques. The purpose of this certificate is to provide students with the specific tools and skills required to prepare them to engage in entrepreneurial activities in Hospitality and Tourism management. Specifically, this certificate will help students create a business plan that includes the financial, human resource, and leadership components vital for their success. What makes the program unique is the inclusion of an optional franchising course to provide students with the expertise needed to consider moving beyond their initial start-up to becoming a franchise in the future.

Upon completion, participants will be able to:

- Create a business plan tailored to entrepreneurial endeavors in Hospitality and Tourism Management;
- Analyze the practical leadership, marketing, financial, and production considerations for a variety of entrepreneurial initiatives for both new ventures and established firms in Hospitality and Tourism Management;
- Analyze and critique both past and current approaches to entrepreneurial leadership;

- Analyze human resources issues relevant to entrepreneurial activities in hospitality and tourism management;
- Apply the processes, practices and legal considerations of entrepreneurial endeavors in hospitality and tourism to real-time cases;
- Analyze and critique the various approaches to franchise concept development, the franchisor-franchisee relationship, franchise agreements, operational problems, and international franchising;
- Apply fundamentals of financial management to cases of entrepreneurial hotels, restaurants, institutions and similar service opportunities

How to Apply:

Fill out the online application for participation in the certificate program.



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Entrepreneurship in Hospitality and Tourism Management EHTC

Address:
7054 Haycock Road
Falls Church, VA 22043

Contact this Certificate

Email Contact(s):

- Professor Mahmood Khan

Web Resource(s):

- Website

Phone Number(s):

- *Mahmood Khan*:
703/538-8486

[Certificate Overview](#)[Admissions & Course Requirements](#)

Entrepreneurship in Hospitality and Tourism Management Admission Requirements

Graduate certificates can be awarded to individuals who do not desire to work toward a degree as well as to students who are working on graduate degrees. Interested students must submit an official copy of their college transcript or diploma documenting receipt of a bachelor's degree from a regionally accredited college or university with an acceptable grade point average mailed to the Virginia Tech Graduate School as part of the application process. Please contact us for specific instructions on applying online. Students should meet with the MSBA-HTM and Graduate Certificates Advisor and submit the application form to the HTM Graduate Administrator for Certificate Program Approval signature no less than six months prior to completion of coursework.

Entrepreneurship in Hospitality and Tourism Management Curriculum Requirements

Number of Credit Hours: 9 credit hours. Transfer credits are not permitted.

Required Course:

MGT 5814 Entrepreneurial Leadership. This course discusses the concepts and techniques for providing leadership in the entrepreneurial venture. It provides the theoretical basis for understanding the entrepreneurial process in the economy. It discusses the practical leadership, marketing, financial, and production considerations for entrepreneurial initiatives for new ventures and established firms. (3H, 3C)

Restricted Elective Courses:

Choose two of the following:

HTM 5424 Human Resource Management. This course focuses upon the attainment and retainment of employees within the hospitality industry. Topics include the processes, practices and legal considerations involved in the employment of people in hospitality organizations. (3H, 3C)

HTM 5464 Franchising in Hospitality Management. Role of franchising in hospitality management. Contemporary issues related to franchising in different segments of hospitality industry, including franchise concept development, franchisor-franchisee relationship, franchise agreements, operational problems, and international franchising. (3H, 3C)

HTM 5444 Financial Management in the Hospitality Service Industries. Fundamentals of financial management as applied to hotel, restaurants, institutions and similar service organizations. (3H, 3C)



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Environmental Politics & Policy PEPC

Address:
Political Science (0130) Major Williams Hall Room 515 220 Stanger Street
Blacksburg, VA 24061

Contact this Certificate

Email Contact(s):

- General Contact
- Graduate Program Director

Web Resource(s):

- Virginia Tech Online

Phone Number(s):

- *General Contact:* 540/231-6572
- *Graduate Program Director:* 540/231-8843

[Certificate Overview](#)

[Admissions & Course Requirements](#)

Certificate Overview

This graduate certificate in Environmental Politics and Policy is designed for non-degree-seeking students and graduate students at Virginia Tech who wish to demonstrate special competence in the research area of environmental politics and policy. This certificate program responds to an existing demand by degree-seeking and non-degree students, studying on campus or through on-line courses. The certificate recognizes coursework that students have completed that demonstrates a focus on environmental politics and policy.

How to Apply:

Fill out the online application for participation in the certificate program.



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Environmental Politics & Policy PEPC

Address:
Political Science (0130) Major Williams Hall Room 515 220 Stanger Street
Blacksburg, VA 24061

Contact this Certificate

Email Contact(s):

- General Contact
- Graduate Program Director

Web Resource(s):

- Virginia Tech Online

Phone Number(s):

- *General Contact:*
540/231-6572
- *Graduate Program Director:*
540/231-8843

[Certificate Overview](#)[Admissions & Course Requirements](#)

Admission Requirements

Applications for the Graduate Certificate in Environmental Politics and Policy will be considered from students enrolled in a graduate degree program at Virginia Tech and from non-degree and Commonwealth Campus students who have undergraduate degrees. Certificates will be awarded upon application for the certificate and application for certificate conferral once course requirements have been completed.

Course Requirements

The certificate requires successful completion of a total of twelve credit hours, of which 9 credits are required courses and 3 are elective. Students need to receive a grade of B or better in each course to receive the certificate. Students will not be allowed to retake a course for a better grade if they receive below a B. All courses are for 3 credit hours. All students must complete:

- * PSCI 5214 Contemporary Political Theory or PSCI 5115 Research Methods I **and**
- * PSCI 5364 Public Ecology
- * PSCI 5584 Environmental Politics and Policy

In addition, students must complete at least 3 credit hours from the following:

- * PSCI 5354 Public Policy Analysis
- * PSCI 5414 Industrial Democracies
- * PSCI 5434 Politics of Developing Areas
- * PSCI 5314 Legislative Branch
- * PSCI 5324 Executive Branch
- * PSCI 5334 Judicial Branch



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Foundations of Political Analysis PPAC

Address:
Political Science (0130) Major Williams Hall Room 515 220 Stanger Street
Blacksburg, VA 24061

Contact this Certificate

Email Contact(s):

- General Contact
- Graduate Program Director

Web Resource(s):

- Website

Phone Number(s):

- *General Contact:*
540/231-6572
- *Graduate Program Director:*
540/231-8843

[Certificate Overview](#)

[Admissions & Course Requirements](#)

Certificate Overview

This graduate certificate program is designed for non-degree-seeking students and graduate students at Virginia Tech who wish to demonstrate special competence in the foundations of political analysis. This certificate responds to an existing demand by degree-seeking and non-degree students, studying on campus or on-line. It will recognize courses that students successfully complete as they focus on developing a foundation in political analysis in political science.

How to Apply:

Fill out the online application for participation in the certificate program.



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Foundations of Political Analysis PPAC

Address:
Political Science (0130) Major Williams Hall Room 515 220 Stanger Street
Blacksburg, VA 24061

Contact this Certificate

Email Contact(s):

- General Contact
- Graduate Program Director

Web Resource(s):

- Website

Phone Number(s):

- *General Contact:* 540/231-6572
- *Graduate Program Director:* 540/231-8843

[Certificate Overview](#)[Admissions & Course Requirements](#)

Admission Requirements

Applications for the Graduate Certificate in Foundations of Political Analysis will be considered from students enrolled in a graduate degree program at Virginia Tech and from non-degree and Commonwealth Campus students who have been permitted to take courses by the Graduate School. Certificates will be awarded upon application for the certificate and application for certificate conferral once course requirements have been completed.

Course Requirements

The certificate requires successful completion of a total of twelve credit hours, of which 9 credits are required courses and 3 are elective. Students need to receive a grade of B or better in each course to receive the certificate. Students will not be allowed to retake a course for a better grade if they receive below a B. All course are for 3 credit hours. All students must complete:

- * PSCI 5214 Contemporary Political Theory
- * PSCI 5115 Research Methods I
- * PSCI 5116 Research Methods II

In addition, students must complete at least 3 credit hours of Political Science graduate course offerings from:

- PSCI 5344 - Political Behavior
- PSCI 5504 - Discourse Analysis



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Future Professoriate FPGC

Address:
Graduate Life Center at Donaldson Brown (0325)
Blacksburg, VA 24061

Contact this Certificate

Email Contact(s):

- Graduate Admissions and Academic Progress

Web Resource(s):

- Website

Phone Number(s):

- *Graduate Admissions and Academic Progress:* 540/231-8636

[Certificate Overview](#)[Admissions & Course Requirements](#)

Future Professoriate Graduate Certificate

For graduate students preparing to become faculty.

This graduate certificate aims to prepare graduate students to become our future faculty and academic leaders by exposure to concepts that break the mold of existing practices in higher education. Many leaders in the academic and business communities have recently challenged colleges and universities to embrace change in order to ensure the viability of the higher education enterprise. Rather than settle for the status quo and witness a probable decline in sustainability, most argue that it is time to create new models and new methods of training for the future professoriate, who will become the faculty and academic leaders of tomorrow.

This certificate is part of the overarching theme "Transformative Graduate Education" ([TGE](#)). Interconnecting components all serve to better prepare the next generations for the professoriate and career professionals.

- Preparing the Future Professoriate
- Preparing the Future Professional
- [GEDI](#) – enhancing the GTA and professional development experience that encourages graduate students to acquire a broad array of skill sets that will prepare them to be teacher/scholar/professionals who are better able to meet the higher education and societal challenges of the 21st century. This project is being conducted in collaboration with Learning Technologies
- [Citizen-Scholar Program](#) – addressing the impact of rigorous intellectual scholarship, leadership and policy beyond the educational realm.

How to Apply:

Fill out the [online application for participation in the certificate program](#).

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Future Professoriate FPGC

Address:
Graduate Life Center at Donaldson Brown (0325)
Blacksburg, VA 24061

Contact this Certificate

Email Contact(s):

- Graduate Admissions and Academic Progress

Web Resource(s):

- Website

Phone Number(s):

- *Graduate Admissions and Academic Progress:*
540/231-8636

[Certificate Overview](#)[Admissions & Course Requirements](#)

Admission Requirements

Graduate students wishing to earn the graduate certificate in Future Professoriate must be currently enrolled master's or doctoral students in any discipline or major. These individuals must have satisfied all admissions requirements to be admitted and must remain in good academic standing.

Course Requirements

Graduate students must complete a minimum of 9 graduate credits (6 of which must be graded graduate credits). Required **core** courses include (6 credit hours):

- [GRAD 5104](#) Preparing the Future Professoriate (3 hours/3 credits)
- [GRAD 5114](#) Pedagogical Practices in Contemporary Contexts (3 hours/3 credits)

To satisfy the additional 3 credits, interested students can selected from this list of [approved courses](#) including the following courses offered by the Graduate School:

- GRAD 5004 GTA Workshop (1 credit hour)
- GRAD 5014 Academic Integrity and Plagiarism (1)
- GRAD 5124 Library Research Skills (1)
- GRAD 5204 Citizen Scholar Seminar (3)
- GRAD 5214 Diversity and Inclusion in a Global Society (3)
- GRAD 5144 Communicating Science (2)
- GRAD 5954 Study Abroad - Future Professoriate Global Perspectives (3)

If you are interested in completing the Future Professoriate Graduate Certificate, please submit the [Graduate Certificate Application](#) to formally enroll in the certificate program. When all certificate requirements have been satisfied, please then submit the [Application for Degree or Certificate Conferral](#) to authorize the issuing of the diploma and the posting of the graduate certificate on your official transcript.



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Geospatial Information Technology GITC

Address:
Department of Geography, 221 Wallace Hall, Virginia Tech
Blacksburg, VA 24061

Contact this Certificate

Email Contact(s):

• Laurence (Bill)
Carstensen

Web Resource(s):

Phone Number(s):

• *Bill Carstensen:*
540/231-2600

[Certificate Overview](#)

[Admissions & Course Requirements](#)

Certificate Overview

Geospatial Information Technology (GIT) includes collection and analysis of remotely sensed data, digital spatial and attribute data used by geographic information systems (GIS), and the application of related technologies such as the Global Positioning System (GPS). Geographic Information Science is one of the leading careers in the United States today.

As depth of knowledge is important to careers in the industry, this certificate requires 12 hours of geospatial coursework. Coursework is taken from one or two categories, beginning with up to two introductory topics if needed, and continuing through more advanced and specialized topics as best fit the student's background and future goals.

How to Apply:

Fill out the online application for participation in the certificate program.



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Geospatial Information Technology GITC

Address:
Department of Geography, 221 Wallace Hall, Virginia Tech
Blacksburg, VA 24061

Contact this Certificate

Email Contact(s):

• Laurence (Bill)
Carstensen

Web Resource(s):

Phone Number(s):

• *Bill Carstensen:*
540/231-2600

[Certificate Overview](#)[Admissions & Course Requirements](#)

Admission Requirements & Procedure

Virginia Tech students accepted in any graduate program category: PhD., MS, MA, Commonwealth Campus, or Non-Degree can be admitted into the GIT program by completing the Graduate Certificate Application, and completing a plan for taking courses required on the course checklist below. Students should meet with an academic adviser familiar with the classes on the list below and submit the application form to Dr. Bill Carstensen for Certificate Program Approval signature no fewer than six months prior to completion of coursework.

Specific steps in the process are:

1. meet with or discuss the choice of acceptable courses with an adviser knowledgeable of the GIT coursework on campus (suggestions are below in additional information),
2. fill out and bring the certificate application form to Dr. Bill Carstensen for signature.
3. submit the signed form to the Graduate School no fewer than six months prior to completion of course requirements,
4. complete 12 hours from the course requirements list below, and
5. submit the completed course check sheet and an unofficial copy of the transcript along with the Application for Degree or Certificate Conferral form to Dr. Bill Carstensen, chair of the Oversight Committee, for a signature, and then take Application for Certificate Conferral Form to the Graduate School.

Course Requirements

Below are the current courses approved for the certificate. Each year additional courses are added in the departments and those may be considered for the certificate if you make a request on your course plan form.

A. Introductory Courses: (0 - 6 credits to cover prerequisites for courses below)

- BSE 5344G - Applied Geographic Information Systems
Conceptual, technical, and operational aspects of geographic information systems as a tool for storage, analysis, and presentation of spatial information. Focus on engineering applications in resource management, site selection, and network analysis. Laboratory work required. Graduate standing required.
- CEE 5204 - Gis Applications in Civil Engineering
Examination of data structures used in geographic information systems. Map projections and coordinate systems used in mapping. Database creation, maintenance, and integrity. Applications of GIS methods for solving civil engineering problems in land management and related areas.
- FREC 5114G - Advanced Information Technologies for Natural Resource Management
Course will introduce students to the theory and applications of database management systems (DBMS) and geographic information systems (GIS). Uses, challenges, and limitations of these technologies in natural resource management application will be discussed.
- FREC 5254 - Remote Sensing of Natural Resources
Philosophy and rationale of remote sensing as a part of the resource management process; comparisons of analogic and digital sensors; sensor selection and proper use; accuracy assessment; signature development; and identification of factors which affect the quality of remotely sensed information.
- GEOG 5064 - Elements of GIS
Foundations and applications of Geographic Information Systems (GIS); geographic coordinate systems, Cartesian map projections, spatial data sources, efficient GIS data structures, map representations, and spatial applications of GIS. Pre: Graduate Standing.

- GEOG 5354G - Advanced Remote Sensing
Theory and methods of remote sensing. Practical exercises in interpretation of aerial photography, satellite, radar, and thermal infrared imagery. Digital analysis, image classification, and evaluation. Applications in earth sciences, hydrology, plant sciences, and land use studies. Field project and report. Review of current research literature. Graduate standing required.
- LAR 5044 - Land Analysis and Site Planning
Introduction to the concepts and methods of ecological resource survey and analysis at regional and site scales. Approaches to environmental problem solving with an emphasis on data collection, evaluation, and synthesis using applicable technologies such as geographic information systems. Interpretation of landscape resource data for the purpose of physical planning and design.
- UAP 5114 - Computer Applications in Urban Planning and Management
An examination of a wide range of computer-based techniques that are of value in analyzing urban and regional planning and management problems. Techniques include linear programming, goal programming; modeling of complex systems; and decision modeling. May be repeated with different content for a maximum of 12 credits.

B. Advanced Courses: (6 -12 credit hours)

- CEE 5224 - Advanced GIS Applications in Civil and Environmental Engineering
This project based course deals with both vector and raster Geographic Information Systems (GIS), network analysis, tracking applications, hydrologic applications, spatial analysis, web databases, and linking GIS to models with programming, specifically in the civil and environmental engineering arena. Pre: Any introductory GIS course, including CEE 5204, GEOG 4084, or BSE 4344. Pre: Graduate standing.
- CEE 5244 - Advanced GIS in Hydrologic Analysis
Advanced GIS course focusing on raster analysis with particular application to the issues associated with hydrologic analysis. Application and evaluation of algorithms for terrain analysis, watershed characterization, and hydrologic analysis and modeling as implemented in GIS. Digital elevation data sources and error assessment. Approaches to GIS/model integration and application. Pre: Graduate standing.
- CS 6604 - Advanced Topics in Data and Information
This course treats a specific advanced topic of current research interest in the area of data and information. Papers from the current literature or research monographs are likely to be used instead of a textbook. Student participation in a seminar style format may be expected. Prerequisite(s): CS 5604 (UG) OR CS 5614 (UG) OR CS 5604 OR CS 5614
- FREC 5104 (GEOG 5104) - Seminar in Remote Sensing & Geographic Information Systems
Interdisciplinary seminar devoted to current research in the fields of remote sensing, Geographic Information Systems, and related topics. Seminars, workshops, and presentations conducted by students, faculty, and visitors. Pre: Graduate standing.
- FREC 5154 - Hyperspectral Remote Sensing
Theory of spectroscopy and spectrometry from portable spectroradiometers to airborne and spaceborne hyperspectral sensors as relevant to natural resource applications, including vegetation species identification and vegetative health, soil and peat properties, mineral and geothermal characteristics, and water applications. Practical investigation of research tools and techniques used to analyze hyperspectral data. Pre-requisite: Graduate Standing Required
- FREC 5264 - GIS Applications in Natural Resource Management
Acquiring and using publicly available natural resources data sources. Methods and algorithms for terrain modeling and landscape metrics. Evaluation of the impacts of data errors and variability on analysis results, including sensitivity analysis of GIS-based resource assessments. Special issues related to temporal data and the management of natural resources information systems.
- FREC 6214 - Forestry Lidar Applications
Theoretical underpinning of established and emerging research using light detection and ranging (lidar) technology for forestry applications including detailed terrain mapping and digital elevation models, canopy height modeling, prediction of forest biophysical parameters, forest physiology and the canopy light regime, watershed mapping and stream modeling, ecological modeling, landscape classifications, and wildlife habitat. Advanced research tools and techniques used to analyze lidar data for different applications. Graduate standing required,.
- GEOG 5034 - Analysis of Spatial Data
Methods of describing and analyzing spatial distributions, including spatial autocorrelation, quadrat analysis, trend surface analysis, and methods of map comparison. Applications to student research problems.
- GEOG 5084G - Advanced Modeling with Geographic Information Systems
Use of automated systems for geographic data collection, digitization, storage, display, modeling and

analysis. Basic data flow in GIS modeling applications. Development of proficiency in the use of current GIS software. Pre: Graduate Standing.

- GEOG 5124 - Aerial Photointerpretation and Analysis
Principles, history, and methods of aerial photographic interpretation. Introduction to photographic systems and application to aerial photography. Human dimension to photointerpretation. Applications to varied fields of knowledge such as land-use mapping, earth sciences, forestry, agriculture, history and archaeology, and military and strategic studies.
- GEOG 5334G - Advanced Geospatial Information Technology for Land Change Modeling
Analysis of the spatio-temporal patterns of land use and Land Cover Change (LULCC) as observed in satellite images. Tropical deforestation, urbanization, and agricultural intensification. Rates and patterns of LULCC linked to biophysical and socio-economic drivers. Impacts of land change with respect to local climate, biodiversity, water yield and quality, and ecosystem services.
- GEOG 5374G - Adv Remote Sensing & Phenology
This course focuses on the analysis of the spatio-temporal of the vegetated land surface as observed in satellite images. Phenological events, such as the first openings of leaf and flower buds, are good indicators of the impact of local and global climate change. The focus of this course will be on satellite image time series used in the derivation of land surface phenology, the appearance and development of phenology other global regions, and the methods developed for the monitoring of phenology with satellite imagery. A major theme will be causes of spatio-temporal changes of phenological events and the effect of global climate change. Pre-requisite: Graduate Standing required
- GEOG 5384 - Programming for Geographic Information Systems
Computational methods of map analysis with the ArcGIS Geographic Information System. Scripting and Visual Basic.NET programming using Environmental Systems Research Institute's ArcObjects library for customization of GIS software to meet research and analytical needs for both the desktop and the web. Pre: 5084G and computer programming experience.
- GEOG 5394G - Web Mapping
Use of web mapping technologies for geographic data collection, storage, analysis, and display. Web mapping topics include history and context, spatial data infrastructures, hardware and software architectures, Open Geospatial Consortium standards, mapping API's, virtual globes, user-centric design, web cartography. Pre: Graduate standing.
- NR 6104 - Advanced Topics in Remote Sensing
In-depth coverage of advanced topics in the field of remote sensing selected to cover emerging techniques and technologies. Examples of topics, which will differ each semester, include field data in support of remote sensing, accuracy assessment, and hyperspectral remote sensing. Critical assessment of the ways in which remotely sensed data and information are employed in varied scientific disciplines and by society.
- STAT 5544 - Spatial Statistics
Spatial data structures: geostatistical data, lattices and point patterns. Stationary and isotropic random fields. Autocorrelated data structures. Semivariogram estimation and spatial prediction for geostatistical data. Mapped and sampled point patterns. Regular, completely random and clustered point processes. Spatial regression and neighborhood analyses for data on lattices.

List of Potential Advisors and Departments

List of Potential Advisors and Departments

- Cully Hession BSE
- Randy Dymond CEE
- Kitty Hancock CEE
- John Galbraith CSES
- Val Thomas FREC
- Randolph Wynne FREC
- Bill Carstensen GEOG
- Jim Campbell GEOG
- Thomas Pingel GEOG
- Yang Shao GEOG
- Mintai Kim LA
- Patrick Miller LA
- Kris Wernstedt UAP NoVA
- Yang Zhang UAP



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Gerontology GRTC

Address:
Center for Gerontology, Virginia Tech, 230 Grove Ln (MC 0555)
Blacksburg, VA 24061

Contact this Certificate

Email Contact(s):

• Center for Gerontology

Web Resource(s):

• Website

Phone Number(s):

• Center for Gerontology:
540/231-7657

[Certificate Overview](#)

[Admissions & Course Requirements](#)

Certificate Overview

The Graduate Certificate in Gerontology is a university-approved program of advanced study offered by the Center for Gerontology. The required minimum of 9 credits focus on three core gerontology competency domains, namely aging processes and outcomes related to (1) biological changes and health, (2) dimensions of psychological functioning, and (3) contemporary social and societal issues. The goal of the curriculum is to offer learning experiences consistent with the recommendations of the Association for Gerontology in Higher Education. The Center for Gerontology is designated a Collaborating Centre by the International Association for Gerontology and Geriatrics (IAGG), signifying that the Center meets IAGG criteria for excellence, including being a sustainable university-level research center, offering a gerontology training program, engaging in research resulting in peer-reviewed publications, and having multiple research affiliates.

How to Apply:

Fill out the online application for participation in the certificate program.



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Gerontology GRTC

Address:
Center for Gerontology, Virginia Tech, 230 Grove Ln (MC 0555)
Blacksburg, VA 24061

Contact this Certificate

Email Contact(s):

• Center for Gerontology

Web Resource(s):

• Website

Phone Number(s):

• Center for Gerontology:
540/231-7657

[Certificate Overview](#)[Admissions & Course Requirements](#)

Admission Requirements

Applicants for the Graduate Certificate in Gerontology must complete the following requirements:

- Obtain admission to the Graduate School in a degree program or as a non-degree student: [Apply here](#).
- Complete the [Center for Gerontology application form](#).
- Complete the [Graduate School Graduate Certificate Application form](#), get signature from the Director of the Center for Gerontology, submit form to the Graduate School, and submit a copy to the Center for Gerontology.
- International students must be able to read, write, and speak English.

Course Requirements

The Graduate Certificate in Gerontology requires 9 credits:

Module #1 – Foundations of Gerontology

- HD 5104 Adult Development & Aging I

Module #2 – Biology/Health

- PHS 5714 Health of the Elderly

Module #3 – Gerontology Elective (3 cr)

- HD 5114 Adult Development & Aging II
- SOC 5714 Aging in Social Context
- 5904 Project and Report
- 5964 Practicum/Field Study
- Other approved course; assignments will be focused on gerontology

Optional Practicum/Field Study

An optional practicum or field study may be arranged through the student's academic department or the Center for Gerontology. The contract or letter of agreement with the host agency is reviewed and signed by the Center's director, the student, an agency representative, and the faculty supervisor before the experience occurs in order for credit to be granted. A copy of the final written report on the internship or field study must be submitted to the Center for Gerontology for the student's file. See [Practicum Guidelines](#) for more details.

Thesis/Dissertation Requirement

The research topic of the thesis or dissertation must be on an issue in adult development and aging. This requirement is not meant to supersede the authority of the student's committee. Its aim is to assure that an issue in gerontology is examined in the research. To meet this requirement:

- Meet with the center associate director to discuss the topic of the thesis/dissertation before completing the proposal.

- After the advisory committee has approved the final draft of the thesis/dissertation, submit a signed cover sheet and abstract to the Center for Gerontology.

Final Documentation

Submit the Graduate School's on-line Application for [Certificate Conferral Form](#) by the Application for Degree deadline. Students applying for a degree and the Certificate conferral in the same semester/summer session will pay only one fee if the forms are submitted at the same time.



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Global Planning and International Development Studies GPIC

Address:
201 Architecture Annex
Blacksburg, VA 24061

Contact this Certificate

Email Contact(s):
• Ralph Hall

Web Resource(s):
• Website

Phone Number(s):

[Certificate Overview](#)

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Certificate Overview

The world is facing enormous challenges in the next century including climate change, water scarcity, world hunger, poverty, rapid urbanization, unemployment, natural habitat loss, resource degradation, and fiscal and institutional mismanagement. To face these challenges, we need thoughtful, ethically informed, and future-oriented solution builders who are thinking at a global scale.

The Graduate Certificate in Global Planning and International Development Studies builds on Virginia Tech's internationally recognized, 40-year specialization in international development planning and an innovative partnership between faculty in programs such as Urban Affairs and Planning, Public Health, Geography, and Building Construction. The certificate seeks to prepare graduate students in multiple disciplines to engage in meaningful global professional leadership and academic positions to systematically tackle and resolve these global planning and development issues.

The certificate may be taken in conjunction with most of Virginia Tech's masters and doctoral degree programs.

How to Apply:
Fill out the online application for participation in the certificate program.



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Global Planning and International Development Studies GPIC

Address:
201 Architecture Annex
Blacksburg, VA 24061

Contact this Certificate

Email Contact(s):
• Ralph Hall

Web Resource(s):
• Website

Phone Number(s):

[Certificate Overview](#)[Admissions & Course Requirements](#)

Admission Requirements

The certificate is open to all graduate students pursuing masters or doctoral degrees at Virginia Tech. Interested non-degree students may be considered for admission on a case-by-case basis. Prospective certificate applicants should confer with their respective graduate degree program academic advisors to ensure that pursuit of the certificate will productively complement their primary graduate degree objectives.

Course Requirements

The core of this graduate certificate focuses on global planning issues and development project design, implementation, and evaluation.

Following the required two-course, six-credit core sequence, students may select an additional six credit hours in three specializations:

- Non-profit and Non-governmental Organization Management and Development
- Sustainable Infrastructure Development
- Public and Environmental Health and Global Development

Additional graduate courses of study in environmental planning and policy, women and gender in international development, natural resources management, homeland and global security, agricultural and rural development, and international business management are also offered at Virginia Tech and may be taken in addition to the three areas of specialization.

Required Core Courses (6 to 9 credit hours)

1. UAP 5764G International Development Policy and Planning (3H), or equivalent course (e.g., UAP 5424: International Policy, Planning, and Management or UAP 5524: International Development) if approved
2. UAP 5764 International Development Planning Studio (3H)

Elective Courses (6 credit hours)

Non-profit and Nongovernmental Organization Management and Development

- UAP 5364 Nongovernmental Organizations in International Development
- UAP 5454 Nonprofit Organization and Management
- UAP 5534 Nonprofit Leadership and Governance
- UAP 5544 Public and Nonprofit Financial Management

Sustainable Infrastructure Development

- UAP 5324 Topics in Infrastructure Planning in Developing Countries
- UAP 5864 Topics in Transportation Policy and Planning
- BC 5144 Sustainable Infrastructure Systems
- UAP 5424 Urban Planning in Europe (1 H)

Public and Environmental Health and Global Development

- PHS 5004 Fundamentals of Public Health
- PHS 5014 Environmental Health
- PHS 5224 Comparative Health Systems
- GEOG 5214 Health and the Global Environment

[Note: The two required elective courses can be selected from two different areas of specialization.]



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Global Sustainability GSC

Address:
Virginia Tech Research Center, 900 North Glebe Road
Arlington, VA 22203

Contact this Certificate

Email Contact(s):

- GCGS Information

Web Resource(s):

- Graduate Certificate in Global Sustainability

Phone Number(s):

- *Center for Leadership in Global Sustainability:*
571/858-3338

[Certificate Overview](#)[Admissions & Course Requirements](#)

GCGS Overview

The Graduate Certificate in Global Sustainability (GCGS) is a 9-credit certificate program offering students an opportunity to gain valuable international experience and awareness while earning graduate credentials from Virginia Tech. With all courses offered virtually, the GCGS is ideal for students from all professions and disciplines, and from around the world, looking to gain experience in global sustainable development.

How to Apply:

Fill out the online application for participation in the certificate program.



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Global Sustainability GSC

Address:
Virginia Tech Research Center, 900 North Glebe Road
Arlington, VA 22203

Contact this Certificate

Email Contact(s):

• GCGS Information

Web Resource(s):

• Graduate Certificate in
Global Sustainability

Phone Number(s):

• *Center for Leadership in
Global Sustainability:*
571/858-3338

[Certificate Overview](#)[Admissions & Course Requirements](#)

GCGS Admission Requirements

Students can apply for the Graduate Certificate in Global Sustainability (GCGS) as a degree-seeking student or non-degree Commonwealth Campus student at Virginia Tech, or as a visiting student from another institution. If you are not currently enrolled as a graduate student you must apply for graduate admission through the Virginia Tech Graduate School as a Graduate Certificate status applicant. Requirements for admission include:

- Completed undergraduate degree
- 2-3 Letters of Recommendation
- Current resume/ CV
- Personal goal statement
- Completed application
- No GRE required; TOEFL may be required for international students

Course Requirements

The GCGS can be completed in a single academic term or over the course of several semesters. A defining element of the certificate program is participating in a Global Study through the required NR 5114 Global Issues in Natural Resources course. All NR courses are offered 100% online.

Required coursework:

- NR 5114 Global Issue in NR (with IFE) - 3 hours
- NR Elective - 3 hours
- NR Elective - 3 hours

As part of our mission to build leadership for global sustainability, Global Study allows students to explore challenges to sustainable development and the innovative cross-boundary strategies being developed to address these challenges. Global Study consists of a 10-day face-to-face team experience in the region of focus, with remaining project work conducted virtually. Global Study provides students with an opportunity to travel, gaining valuable real-world international and cross-cultural experience. Upcoming IFEs are scheduled for:

- Cuba (Fall 2019)
- China (Spring 2020)
- Croatia (Summer 2020)
- Morocco (Fall 2020)
- India (Spring 2021)
- South Africa (Summer 2021)
- Cuba (Fall 2021)



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Health Information Technology HITC

Address:
VT-MIT Program Northern Virginia Center 7054 Haycock Road, Suite 365
Falls Church, VA 22043

Contact this Certificate

Email Contact(s):

- MIT Email

Web Resource(s):

- MIT Website
- MIT Certificates Website

Phone Number(s):

- MIT Office:
703/538-8384

[Certificate Overview](#)[Admissions & Course Requirements](#)

Graduate Certificate in Health Information Technology

The healthcare industry is ever evolving. With the adoption of electronic medical records, telemedicine, and the International Classification of Diseases Tenth Edition (ICD-10) migration, there is demand for those with skills in both information technology and the healthcare field. The certificate in Health Information Technology aims to provide competence in patient informatics and the use of evidence based medicine, electronic prescribing, and telemedicine as tools to improve patient health and medical systems operation through grounding in health record organization from the multiple perspectives of patients, technicians, nurses, hospital administration, and insurance companies. Students will understand the use of business intelligence and analytics in data rich organizations and obtain the ability to develop and apply business intelligence and analytics solutions to various types of decision problems.

Target Audience and Time to Complete:

The target audience is Virginia Tech graduate students who are interested in adding expertise in health information technology to that gained in their current degree program.

However, we also expect that a number of other professionals will pursue the certification both for job knowledge and career enhancement. Those students will be admitted as non-degree seeking, MIT-Commonwealth students.

In most cases time to completion will be two semesters. Degree-seeking students may take courses in conjunction with their regular course load. Students attending full-time can complete the certificate in a minimum of one academic year and a maximum of four academic years. Degree-seeking students attending part-time can complete the certificate in approximately two academic years and a maximum of three academic years.

Non-degree seeking, full-time students can complete the certificate in a minimum of one academic year (two semesters). Non-degree seeking, part-time students, taking one course per semester, can complete the certificate in two academic years (four semesters).

[Master of Information Technology \(MIT\) Program](#)

[MIT Graduate Certificates](#)

How to Apply:

Fill out the online application for participation in the certificate program.



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Health Information Technology HITC

Address:
VT-MIT Program Northern Virginia Center 7054 Haycock Road, Suite 365
Falls Church, VA 22043

Contact this Certificate

Email Contact(s):
• MIT Email

Web Resource(s):
• MIT Website
• MIT Certificates Website

Phone Number(s):
• MIT Office:
703/538-8384

[Certificate Overview](#)[Admissions & Course Requirements](#)

Admissions Requirements for the Graduate Certificate in Health Information Technology

Admission to the Graduate School and completing a Graduate Certificate Application are required for both degree- and non-degree seeking students.

Degree-seeking applicants: The Graduate School requires completion of a bachelor's degree from an accredited institution with a GPA of 3.0 or better for admission to Certificate Status. Applicants with an undergraduate GPA < 3.0 may qualify for Commonwealth Campus admission. Students pursuing a degree and a certificate simultaneously are classified within their degree program.

For students interested in pursuing both the Master's degree in MIT and the certificate in Information Technology Management no more than fifty percent of certificate courses will be included toward completion of the MIT degree.

Non-degree seeking applicants: A qualified person who wishes to enter Virginia Tech to obtain a graduate certificate, without being enrolled in a degree program, may apply for graduate admission to Graduate Certificate by completing the [certificate application](#).

Applicants must meet the following criteria:

- GPA of 3.0 for admission for the last half of the credits earned for the undergraduate (bachelors) degree*
- Official transcripts must be submitted
- Academic background meets the requirements of the admitting academic unit
- International Applicants must submit scores from the Test of English as a Foreign Language (TOEFL) or International English Language Testing System (IELTS). A minimum TOEFL score of 550 paper-based (PBT) or 80 internet-based test (iBT) is required for consideration of the application. On the iBT, sub-scores of at least 20 on each subject test (Listening, Speaking, Reading, and Writing) are required for admission. A minimum IELTS score of 6.5 is required for admission. Some departments have higher TOEFL or IELTS score requirements than those set by the Graduate School.

[Admissions - MIT Graduate Certificates](#)

Course Requirements for the Graduate Certificate in Health Information Technology

Number of Credit Hours:

A total of nine credit hours are required. Transfer credits are not permitted. Students must maintain a minimum GPA of 3.0 in the designated courses.

Required Courses:

ACIS 5504 – Information Systems Design & Database Concepts: This course is an introduction to design methodologies in information systems. Structured systems analysis and design methodologies are discussed. An introduction to database design methodologies is also included. Topics related to different database models and their implementation is discussed. Students are also required to design and implement information systems using appropriate computer software.

BIT 5564 – Healthcare Information Technology: Use of information technology in the health care industry. Topics address electronic health records, patient informatics, evidence based medicine, electronic prescribing and telemedicine. The use of these technologies to improve patient health and medical systems operations.

BIT/ACIS 5574 – Healthcare Data Management: Organization and management of data in the health care

industry. Includes standards for electronic health records, healthcare enterprise systems architecture, health database design, existing database platforms, data integration from multiple sources, database accessibility. Analysis of healthcare-related organizations from the perspective of multiple user groups including patients, technicians, nurses, physicians, clinics, hospitals and insurance companies

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Higher Education Administration HEAC

Address:
1750 Kraft Dr. Suite 2000
Blacksburg, VA 24060

Contact this Certificate

Email Contact(s):
• Claire Robbins

Web Resource(s):
• Website

Phone Number(s):
• Office Phone::
540/231-2004

[Certificate Overview](#)

[Admissions & Course Requirements](#)

Certificate Overview

The graduate certificate program in Higher Education Administration targets full-time college administrators who may not have studied higher education through any formal degree program but wish to develop a deeper understanding of the environment in which they work. Doctoral students engaged in other disciplines who plan to enter the academy as faculty members may also benefit from this certificate program.

How to Apply:

Fill out the online application for participation in the certificate program.



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Higher Education Administration HEAC

Address:
1750 Kraft Dr. Suite 2000
Blacksburg, VA 24060

Contact this Certificate

Email Contact(s):
• Claire Robbins

Web Resource(s):
• Website

Phone Number(s):
• Office Phone::
540/231-2004

[Certificate Overview](#)[Admissions & Course Requirements](#)

Admission Requirements

Those who wish to seek the certificate need to be admitted to a graduate degree program (<https://ess.graduateschool.vt.edu/pages/login.php>), or admitted as a non-degree seeking or a Commonwealth Campus student (<https://gradapp.stl.vt.edu/pages/login.php>). In addition to the appropriate admission application, students must complete the Application for a Graduate Certificate (<http://graduateschool.vt.edu/admissions/applying/index.html>). The Graduate School requires a GPA of 3.0 for admission to Certificate Status and official transcripts must be submitted.

Students already enrolled in a graduate degree program at Virginia Tech should submit the Application for a Graduate Certificate (<http://graduateschool.vt.edu/admissions/applying/index.html>). Note that students pursuing a degree and a certificate simultaneously are classified in their degree program. Six of the credits used toward a certificate may be used in meeting degree requirements if they are appropriate for inclusion on the Plan of Study for the degree.

Enrollment may be limited based on class size. Certificates will be awarded upon the student's application for the certificate once they have successfully completed the course requirements and submitted the [Application for Conferral of Degree or Certificate](#) form.

Course Requirements

The certificate requires successful completion of a total of 12 credit hours, of which 6 credits are required courses and 6 credits are elective. Students need to receive a grade of B or better in each course to receive the certificate. Students receiving a grade below a B will have to re-take the course before credit will be awarded. All courses are 3 credit hours and are offered annually or every other year, depending upon availability of the faculty.

All students must complete:

EDHE 6064 – Higher Education in the United States (Fall)
EDHE 6274 – Higher Education Law (Fall)

In addition, students must complete the two courses in one of the following three tracks:

Student Development and Learning Track

EDHE 5314 – Theories of Student Development (Fall)
EDHE 5334 – The College Student and the College Environment (Spring)

Governance and Policy Track

EDHE 6084 – Financial Administration in Higher Education (Spring, Odd Numbered Years)
EDHE 6044 – Governance and Policy in Education (Spring, Even Numbered Years)

Organizations and Management Track (please contact Claire Robbins for more information if you are interested in this option)

EDHE 6304 – Theories of Educational Organizations
EDHE 6094 – University Leadership

Eligibility

Those enrolled as graduate degree seeking or Commonwealth Campus (non-degree seeking) students are eligible to receive a Certificate in Higher Education Administration.

For more information, please contact Dr. Claire Robbins at robbinsc@vt.edu.

To access Virginia Tech's Equal Opportunity/Affirmative Action statement, please [visit this page](#).

Location

Faculty members in the Higher Education program hold offices in Suite 2000 of the building located at 1750 Kraft Drive, Blacksburg, Virginia 24060. This building is situated in the Corporate Research Center, opposite the airport and just off Research Center Drive.



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Homeland Security Policy HSC

Address:
900 N. Glebe Rd
Arlington, VA 22203

Contact this Certificate

Email Contact(s):

- Patrick Roberts
- Jeff Glick

Web Resource(s):

- Website
- Certificate Website

Phone Number(s):

- *Scott Weimer:*
540/231-7887
- *Stephanie Smith:*
571/858-3163

[Certificate Overview](#)

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Certificate Overview

The graduate certificate in homeland security focuses on U.S. domestic security and emergency management issues. The certificate serves either as a stand-alone credential of advanced educational achievement for non-degree students or as a supplement to a master's or doctoral degree. Four homeland security courses will introduce students to the complexity of the homeland security environment, from analyzing the terrorist threat, to considering questions of hazard mitigation, preparedness, and resilience, to investigating response and recovery strategies.

Taught by a mix of scholars and practitioners, the certificate addresses issues of homeland security strategy, policy design, planning, operations, managing across and among networks, and implementation.

The certificate is composed of four courses (12 hours of graduate coursework). The core courses focus on 1) the threat (PAPA 5264), 2) prevention (PAPA 6264), and 3) response and recovery (PAPA 5354). A fourth course is selected from specified electives.

The certificate is open to non-degree students as well as degree seeking graduate students across Virginia Tech. MPA students may use the certificate as their concentration and reflect upon the certificate and homeland security issues in their portfolio or internship. Ph.D. students may use the certificate as a foundation for dissertation research in homeland security policy and management. Transfer credits are not permitted.

Please Note: The certificate requirements will be changed as of Spring 2021 to require only the three core courses listed above; no additional elective will be required.

How to Apply:

Fill out the online application for participation in the certificate program.



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Homeland Security Policy HSC

Address:
900 N. Glebe Rd
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Contact this Certificate

Email Contact(s):

- Patrick Roberts
- Jeff Glick

Web Resource(s):

- Website
- Certificate Website

Phone Number(s):

- *Scott Weimer:*
540/231-7887
- *Stephanie Smith:*
571/858-3163

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Admission Requirements

Non-degree candidates may apply for admission to the certificate program using the Virginia Tech Graduate School's online application system found at [Admissions](#). Interested students must submit an official copy of their college transcript documenting receipt of a bachelor's degree from a regionally accredited college or university with an acceptable grade point average mailed to the Virginia Tech Graduate School as part of the application process. Current graduate students also may pursue the certificate.

Course Requirements

Students must take four courses (12 hours), including three required classes to receive the certificate.

Required:

- PAPA 5254 Homeland Security and the Terrorist Threat
- PAPA 6264 Advanced Topics in Policy Systems Management
*or when the topic is focused on homeland security.
- PAPA 5354 Homeland Security Response and Recovery

Electives (choose one):

- PAPA/STS 6664 Advanced Topics in Science and Technology: Complexity, Emerging Policy, Doctrine, and Reality
- PAPA 6254 Advanced Topics in Homeland Security Policy: Critical Infrastructure Protection and Resiliency
- GIA 5514 Global Security
- PAPA 5904/5974 Independent Study, Project and Report

Effective Spring 2021, only the three core courses will be required.

Changes in Spring 2021

The certificate requirements will be changed as of Spring 2021 to only require the three core courses and no additional elective will be required.



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Hospitality and Tourism Analytics and Revenue Management HTAC

Address:
7054 Haycock Road
Falls Church, VA 22043

Contact this Certificate

Email Contact(s):

- Professor Mahmood Khan

Web Resource(s):

- Website

Phone Number(s):

- Mahmood Khan:
703/538-8486

[Certificate Overview](#)[Admissions & Course Requirements](#)

Hospitality and Tourism Analytics and Revenue Management Certificate Overview

This graduate certificate will provide middle managers in the Hospitality and Tourism industry with the tools and skills required to engage in high-level strategic thinking and analysis in the areas of revenue management and business analytics. Specifically, this certificate will provide methods to utilize information systems as tools for dynamic forecasting of supply and demand and maximize profits in HTM-related businesses. Skills gained will ultimately allow certificate holders to compete for upper level managerial positions.

Upon completion, students will be able to:

- Determine the strategic roles of information systems in today's hospitality/tourism organizations.
- Implement information technology applications.
- Apply the components of Web marketing and distribution practices.
- Compare and contrast information systems that support business intelligence and data analytics in hospitality/tourism.
- Evaluate emerging data analytics tools in operations and strategic decision making.
- Analyze effectiveness and return on investment of information systems.
- Evaluate revenue management (RM) as a dynamic strategic process.
- Create and implement an effective RM process.
- Implement RM within the framework of Customer Relationship Management.

- Analyze the key elements of dynamic forecasting of demand, supply, cancellations and no-shows.
- Apply the key elements of setting RM controls and rate fences / restrictions.
- Analyze positioning, segmentation, target market selection, product development, pricing and channel management within the context of RM policies and processes.
- Manage the interface between revenue management with human resources and information systems management in hospitality service environments.
- Articulate and debate the ethical aspects of revenue management in hospitality services environments.

How to Apply:

Fill out the online application for participation in the certificate program.



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Hospitality and Tourism Analytics and Revenue Management HTAC

Address:
7054 Haycock Road
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Email Contact(s):

- Professor Mahmood Khan

Web Resource(s):

- Website

Phone Number(s):

- Mahmood Khan:
703/538-8486

[Certificate Overview](#)[Admissions & Course Requirements](#)

Hospitality and Tourism Analytics and Revenue Management Admission Requirements

Number of Credit Hours:

Graduate certificates can be awarded to individuals who do not desire to work toward a degree as well as to students who are working on graduate degrees. Interested students must submit an official copy of their college transcript or diploma documenting receipt of a bachelor's degree from a regionally accredited college or university with an acceptable grade point average mailed to the Virginia Tech Graduate School as part of the application process. Please contact us for specific instructions on applying online. Students should meet with the MSBA-HTM and Graduate Certificates Advisor and submit the application form to the HTM Graduate Administrator for Certificate Program Approval signature no less than six months prior to completion of coursework.

Hospitality and Tourism Analytics and Revenue Management Course Requirements

9 credit hours. Transfer credits are not permitted.

Required Courses:

HTM 5564 Information Technology and Business Analytics in Hospitality and Tourism. Study of the most widely used information systems in operation, management, and e-business in hospitality and tourism. Study of emerging data analytics tools for business intelligence and strategic decision making. Study of impacts of IT on organizations and the industry overall. (3C)

HTM 5574 Revenue Management for Hospitality Services. Dynamic forecasting of supply and demand, customer relationship management, services production, pricing, promotion, and distribution. Implications for human resources and information systems management. Application and integration of revenue and customer centric management theory. (3C)

Restricted Elective Courses:

Choose one of the following:

MGT 5804 Strategic Leadership in Technology-based Organizations (online). This course

focuses on the role of the leader in crafting corporate and business strategies where technology provides the basis for the firm's competitive advantage. It helps students understand the root causes of common problems in innovation, showing how these can manifest themselves symptomatically in various stages of the development process, and in different areas of the company. The aspiration of this course is first to help managers build the tools to understand the real, underlying reasons why efforts to innovate so often fall short of expectations - and then with that understanding as a foundation, to learn how to build action plans that resolve the root problems. (3C)

BIT 5594 Web Applications and E-Commerce (online). An examination of the concepts, technologies, and applications of electronic commerce. Topics include the World Wide Web as a platform for electronic commerce; intranets; electronic data interchange; electronic banking and payment systems; security and firewalls; software agents; and the social, legal, and international issues of electronic commerce. (3C)



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Human Centered Design HCDC

Address:
Department of Computer Science 1121 VTKW II 2202 Kraft Dr #0902
Blacksburg, Virginia 24060

Contact this Certificate

Email Contact(s):
• Steve Harrison

Web Resource(s):

Phone Number(s):
• Steve Harrison:
540/231-7783

[Certificate Overview](#)[Admissions & Course Requirements](#)

Human-Centered Design Overview

An introduction to human-centered design benefits your graduate research and broadens your career prospects. Whether studying to be a designer, engineer, scientist or artist, your work ultimately impacts real people. Taking users seriously improves how projects are conceived and executed.

Design matters. The act of creating something new shows up in many human endeavors. It can be a solution to a mundane problem like holding sheets of paper together or something as complex as the formulation of new institutions. Human Centered Design (HCD) is an approach to design charged with understanding the needs, wants, and limitations of end-users. This is accomplished through methodologies and practices where these considerations are integrated at every stage of the design process.

In the Certificate program, students learn the core ideas of HCD, explore how it applies in their own professional domains, and discover how their own research connects with projects in other disciplines. In particular, it leverages inter-disciplinarity to see how to learn from the world around. The ability to collaborate across disciplines is a high-demand skill set in the private and public sectors and higher education careers, because institutions recognize that creative solutions to the most important societal challenges requires integrating aesthetics, analysis, and technological development.

How to Apply:
Fill out the online application for participation in the certificate program.



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Human Centered Design HCDC

Address:
Department of Computer Science 1121 VTKW II 2202 Kraft Dr #0902
Blacksburg, Virginia 24060

Contact this Certificate

Email Contact(s):
• Steve Harrison

Web Resource(s):

Phone Number(s):
• Steve Harrison:
540/231-7783

[Certificate Overview](#)[Admissions & Course Requirements](#)

HCD Certificate Admission Requirements

Any student who has gained admission to a graduate program at Virginia Tech is eligible to take part in the Human-Centered Design (HCD) Certificate program.

HCD Course Requirements

The graduate certificate requires completion of 12 credit hours, with 6 credits prescribed, and 6 credits selected from two of three areas. Take both courses from the 'Required' section below, then choose at least 1 more course from any two of the areas 1, 2, and 3 for a total of 12 credits. (The elective courses should be in different areas.)
NOTE: this list of classes has changed from previous years; students who have completed or were completing the certificate based on previous posted course requirements may use those courses for the certificate. If you have questions, please contact Steve Harrison, director.

Required: INTERDISCIPLINARY RESEARCH

- GRAD 5134: Topics in Interdisciplinary Research (when HCD topic is offered)
- CS 5724: Models and Theories of Human-Computer Interaction

1. DESIGN STUDIES

- ART 5524: Topics in Human Centered Design (studio)
- ENGE 5024: Design in Engineering Education and Practice
- STS 6614: Adv. TS: (Cultures of Design; Origins of Innovation)

2. UNDERSTANDING PEOPLE

- CS/ISE 5714: Usability Engineering
- CS 5734: Computer-Supported Collaborative Work
- EDIT 5234: Intro to the Learning Sciences
- ENGE 5404: Assessment Techniques in Engineering Education
- ISE 5604: Human Information Processing I
- ISE 6604: Human Factors in Visual Display Systems
- ISE 6984: Cognitive Task and Work Analysis
- PSYCH 5354: Information Processing
- STS 6244: TS: History, Culture, and Politics of the Internet

3. DESIGN REALIZATION

- ART 5714: TS: Creative Code for Art & Design; TS: Interaction Design
- CS 5764: Information Visualization
- CS 5774: User Interface Software
- CS 6724: Advanced Topics In Human Computer Interaction
- ECE 5564: Wearable + Ubiquitous Computing
- EDIT 5624: Interactive Learning Media, Arts, and Design
- EDIT 5614: Digitally Mediated Learning
- EDIT 5624: Interactive Learning Media, Arts, and Design
- EDIT 5634: Interactive Learning Media Development
- ENGL 5074: Introduction to Digital Humanities
- ENGL 6344: Rhetoric in Digital Environments
- ISE 6604: Human Factors in Visual Display Systems
- ISE 6614: Human Computer Systems
- ME 5644: Rapid Prototyping

Human-Centered Design and Human-Computer Interaction certificate programs

For graduate students interested in the design of interactive systems, there are two graduate certificates: the Human-Centered Design certificate and the Human-Computer Interaction certificate.

- The **HCD certificate program** focuses on creating the “new” – that is, design. It does so through the application of a “human-centered” paradigm; some key human-centered methodologies are participatory design and user experience design. Designing this way can be applied in many areas from consumer products to computer interfaces.
- The **HCI certificate program**, in contrast, does not emphasize (or even require) design. It focuses specifically on computer and information system interfaces. There are many ways of knowing what constitutes a “good” interface and the certificate program approaches the question using research, evaluation and design ways of knowing.

Thus, the two certificate programs complement one another. It is possible to attain both certificates with careful planning of additional course work and selection of thesis or dissertation topics. Courses may be counted towards no more than two credentials (certificates and degrees).

2013-2015 course list

The following is the previous course list. It is provided for those students who have already begun the HCD Certificate program:

The graduate certificate requires completion of 12 credit hours, with 6 credits prescribed, and 6 credits selected from across two of three areas. Take both courses from the ‘Required’ section below, then choose 2 more courses from area 1, 2, or 3 for a total of 12 credits.

REQUIRED

GRAD 5134: Topics in Interdisciplinary Research (3 credits- when HCD topic is offered)

ART 5524 (ART 5984 Fall 2014): Topics in Human Centered Design (3 Credits, Fall only)

Area 1: Creative Problem Solving

ART 5714: TS: Creative Code for Art & Design; TS: Interaction Design

EDIT 5624: Interactive Learning Media, Arts, and Design

ENGE 5024: Design in Engineering Education and Practice

ME 5644: Rapid Prototyping

Area 2: Computational Practices

CS/ISE 5714: Usability Engineering

CS 5724: Models and Theories of HCI

CS 5764: Information Visualization

CS 5774: User Interface Software

CS 6724: Advanced Topics In Human Computer Interaction

ECE 5564: Wearable + Ubiquitous Computing

EDIT 5624: Interactive Learning Media, Arts, and Design E

EDIT 5634: Interactive Learning Media Development

ISE 5604: Human Information Processing I

ISE 6614: Human Computer Systems

ISE 6604: Human Factors in Visual Display Systems

Area 3: Interdisciplinary Research

EDIT 5234: Intro to the Learning Sciences

EDIT 5614: Digitally Mediated Learning

ENGE 5404: Assessment Techniques in Engineering Education

ENGL 5074: Introduction to Digital Humanities

ENGL 6344: Rhetoric in Digital Environments

STS 6244: TS: History, Culture, and Politics of the Internet

STS 6614: Adv. TS: (Cultures of Design; Origins of Innovation)



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Human Factors of Transportation Safety HFTC

Address:
3500 Transportation Research Plaza (0536)
Blacksburg, VA 24061

Contact this Certificate

Email Contact(s):

• Jon Antin, Ph.D., CHFP,
Program Coordinator

Web Resource(s):

• Human Factors of
Transportation Safety
Graduate Certificate
Program

Phone Number(s):

• Jon Antin, Ph.D., CHFP,
Program Coordinator:
540/231-1579

[Certificate Overview](#)[Admissions & Course Requirements](#)

Certificate Overview

The Human Factors of Transportation Safety Graduate Certificate Program (HFTS GCP) focuses on the driver characteristics, states, behaviors, and performance factors that, in interaction with vehicle, traffic, and roadway factors, have a major influence not only on mitigating the deleterious effects of crashes, but on actively avoiding them altogether. Virginia Tech is uniquely positioned to offer such a program by integrating the strengths of the Virginia Tech Transportation Institute (VTTI) in partnership with the following academic departments, as all of these are already focusing on integrating human factors into their curricula and research programs:

- [Biomedical Engineering and Mechanics](#)
- [Civil and Environmental Engineering](#)
- [Industrial & Systems Engineering](#)
- [Psychology](#)
- [Statistics](#)

The HFTS Graduate Certificate Program is housed and administered within VTTI (with support from the Graduate School and affiliated faculty of the partnering departments). It is important to note that the Certificate must be pursued as an integral part of the student's Master's or Doctoral matriculation plan at Virginia Tech; it may not be pursued independently.

Mission Statement: *Create and deliver in-depth knowledge and marketable skills applied to the research, evaluation, maintenance, improvement, and protection of all transportation users and their communities via the application of human factors theories, tools, and methods; and to train the next generation of leaders in the field of the human factors of transportation safety within the Commonwealth and across the Nation.*

For many years, Virginia Tech has been offering a number of undergraduate and graduate courses with relevance to the human factors issues associated with transportation safety. Offering the HFTS GCP as an option to graduate students at Virginia Tech appropriately emphasizes the ever-increasing importance of this field and focuses student learning and skills acquisition on a comprehensive domain of knowledge and skills. The HFTS Certificate provides students the requisite advanced skills and expertise necessary to join the transportation safety field in industry as well as research communities. The integration and expansion of human factors-related transportation safety offerings at Virginia Tech will continue to contribute effectively to the enhancement of transportation safety state-wide, nationally, and internationally.

Course Requirements Overview

§ Four courses must be selected from a structured menu of options (see Course Requirements section for details).

§ Courses from at least 3 of the 5 affiliated departments noted above must be represented in the student's *overall graduate program of study*.

How to Apply:

Fill out the online application for participation in the certificate program.



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Human Factors of Transportation Safety HFTC

Address:
3500 Transportation Research Plaza (0536)
Blacksburg, VA 24061

Contact this Certificate

Email Contact(s):

• Jon Antin, Ph.D., CHFP,
Program Coordinator

Web Resource(s):

• Human Factors of
Transportation Safety
Graduate Certificate
Program

Phone Number(s):

• Jon Antin, Ph.D., CHFP,
Program Coordinator:
540/231-1579

[Certificate Overview](#)[Admissions & Course Requirements](#)

Admission Requirements

- Admission to the Graduate School
- Completing a Graduate Certificate Application is required for all students.
- Courses applied towards certificate credit must be part of an approved program of study.

Course Requirements

The certificate requires a total of 4 courses distributed as follows:

One course from *each* of Categories A, B, and C, and one course from *either* Category D or E

Category A: Transportation Safety / Risk Core

- **BMES 5984** Advanced Vehicle Safety Systems
- **CEE 5640** Highway Transportation Safety

Category B: Human Factors Core

- **ISE 5604** Human Information Processing
- **ISE 5605** Human Factors Systems Design I
- **PSYC 5344** Cognitive Psychology

Category C: Statistics and Research Design

- **ISE 5615** Human Factors Research Design
- **PSYC 5315** Research Methods
- **STAT 5374** Statistical Epidemiology and Observational Studies
- **STAT 5615/5616** - Statistics in Research

Category D: Transportation-Related Eng./ Modeling / Design

- **BMES 5164** Advanced Impact Biomechanics

- **BMES 5174** Biomechanics of Crash Injury Prevention
- **BMES 6164** Computational Modeling in Impact Biomechanics
- **BMES 6174** Advanced Human Modeling: Injury and Tissue Biomechanics
- **CEE 5604** Traffic Characteristics and Flow
- **CEE 5644** Transportation Systems Planning
- **CEE 5654** Advanced Geometric Design & Highway Safety

Category E: Human Factors Aspects of Transportation

- **CS/ISE 5714** Usability Engineering
- **ISE 5644** Human Audition and Auditory Display Design
- **ISE 6604** Human Factors in Visual Display Systems
- **ISE 6614** Human Computer Systems
- **ISE 6624** Advanced Topics in Human Factors [1]
- **PSYC 5404** Biological Bases of Behavior
- **PSYC 6404** Behavior Management in Large-scale Systems
- **STAT 5204** Experimental Design and Analysis I
- **STAT 5204G** Experimental Design: Concepts and Applications
- **STAT 5214G** Advanced Methods of Regression Analysis
- **STAT 5514** Regression Analysis

Thesis/Dissertation Topic & Optional Research Internship

- Thesis/Dissertation topic must be transportation safety related (and approved by the Human Factors of Transportation Safety Graduate Certificate Program administrative body as well as the student's graduate committee)
- If the student chooses the project option, it must be transportation safety related, *and* the student must take an additional course (5 total courses), with the fifth course being selected from any category within the HFTS GCP menu, A-E.
- Optional research internship for one semester up to one year at VTTI or equivalent opportunity (e.g., NHTSA, GM, etc. [can earn up to 6 research credit hours and up to 3 independent study credit hours per semester of internship]) – note that these optional hours/experiences do not substitute for any of the 12 required credit hours.
- Prior to filling in the Graduate School's Certificate Application Form, the prospective student should first contact the HFTS Program Coordinator.



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Human Sexuality Studies HSSC

Address:
315 Wallace Hall, 295 West Campus Dr.
Blacksburg, VA 24061

Contact this Certificate

Email Contact(s):

Web Resource(s):

Phone Number(s):

[Certificate Overview](#)[Admissions & Course Requirements](#)

Certificate Overview

The VT Graduate Certificate in Human Sexuality Studies program draws on diverse and interdisciplinary perspectives to produce insights into how sexual expression, behavior, and representation are shaped by multiple intersecting individual and cultural contexts, and how they, in turn, shape the health and well-being of individuals, communities, and populations.

Graduate students engage in research and take three core courses (9 credits) covering sexuality from life-course/development perspectives, feminist/queer theory perspectives, and public health/human rights perspectives. While both broadening and deepening student knowledge about the psychological, familial, social, cultural, and political aspects of human sexual behavior and health from a global perspective, this program encourages intercultural understanding, problem-solving, and social responsibility.

Core Courses:

HD 5344 Perspectives on Human Sexuality

PHS/HD/WGS 5244 Sexual Health and Human Rights

WGS 5934 Sexualities and Queer Theory

How to Apply:

Fill out the online application for participation in the certificate program.

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Human Sexuality Studies HSSC

Address:
315 Wallace Hall, 295 West Campus Dr.
Blacksburg, VA 24061

Contact this Certificate

Email Contact(s):

Web Resource(s):

Phone Number(s):

Certificate Overview

Admissions & Course Requirements

Admissions Requirements

Graduate students who have already been accepted into any graduate program or graduate studies at Virginia Tech can apply to the certificate program. To apply, please complete the following materials and contact the program Director:

1. A **Letter of Interest** (250–500 words: include your past work experience, your long-range education and career objectives, and your reasons for applying to the Certificate)
2. A copy of your most recent **Curriculum Vitae** (CV/resume)
3. A **VT Graduate Certificate Application form** (available at: https://graduateschool.vt.edu/content/dam/graduateschool_vt_edu/GAAPforms/Application_Certificate.pdf)

For more information, please contact Dr. Christine Kaestle, the Human Sexuality Studies Program Director, at kaestle@vt.edu.

Curriculum Requirements

The graduate student's research agenda must relate to human sexuality, as approved by the program director. Students are required to take three core courses:

HD 5344 Perspectives on Human Sexuality (3 cr). Interdisciplinary historical consideration of writings, research, theory, and application of knowledge related to human sexuality from developmental and family studies perspectives.

PHS/HD/WGS 5244 Sexual Health and Human Rights (3 cr). Sexual and reproductive health from human development, public health, and critical feminist perspectives, with special attention to human rights issues. Sexually transmitted infections; HIV/AIDS; unintended pregnancy; population policies; eugenics; sexual and reproductive rights; positive sexuality, sex education; and health promotion.

WGS 5934 Sexualities and Queer Theory (3 cr). Theoretical perspectives of queer studies and its influence on sexuality studies. Historical and cultural constructs of sexuality and gender. Queer epistemologies that implicate traditional notions of technology, identity, desire, normativity, and social control. Intersections of gender, race, sexuality, ethnicity, class, age, transnational borders, and (dis) ability.



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Human-Computer Interactions HCIC

Address:

Blacksburg, VA 24061

Contact this Certificate

Email Contact(s):

• Dr. Scott McCrickard

Web Resource(s):

• Website

Phone Number(s):

[Certificate Overview](#)[Admissions & Course Requirements](#)

Certificate Overview

A Graduate Certificate in Human-Computer Interaction (HCI) Program is administered by the Center for Human-Computer Interaction and offered in conjunction with either a master's or doctoral degree in most departments. It gives graduate students the opportunity to develop their skills in HCI through courses and through their thesis or dissertation work.

How to Apply:

Fill out the online application for participation in the certificate program.



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Human-Computer Interactions HCIC

Address:

Blacksburg, VA 24061

Contact this Certificate

Email Contact(s):

• Dr. Scott McCrickard

Web Resource(s):

• Website

Phone Number(s):

[Certificate Overview](#)

[Admissions & Course Requirements](#)

Admission Requirements

Any student who has gained admission to a graduate program at Virginia Tech is eligible to take part in the HCI Certificate program.

Course Requirements

Master's degree students complete 9 hours and doctoral students 15 hours of coursework for the certificate; at least two of the courses taken must be outside the student's degree program requirements and home department. These courses should be relevant to HCI; any exceptions to courses not on the web site must be cleared by the certificate coordinator. If the student writes a thesis or dissertation, it must be related to human-computer interaction. Students can normally fit the requirements for the certificate into their program of graduate study so that the time needed to complete the graduate degree in their basic discipline is not extended by simultaneously pursuing the certificate.

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Human-System Integration HSIC

Address:
VT ISE Department 250 Durham Hall (0118) Blacksburg, VA 24061
Blacksburg, VA 24061

Contact this Certificate

Email Contact(s):
• Hannah Parks

Web Resource(s):
• HSI Certificate

Phone Number(s):
• *Hannah Parks*:
540/231-5586

[Certificate Overview](#)

[Admissions & Course Requirements](#)

Human-System Integration

A four-course academic program that serves to expand and improve systems management and engineering practice, with emphasis on “human-technology interface” at various levels in the hierarchy and throughout the life cycle of complex technological and enterprise systems.

How to Apply:

Fill out the online application for participation in the certificate program.



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Human-System Integration HSIC

Address:
VT ISE Department 250 Durham Hall (0118) Blacksburg, VA 24061
Blacksburg, VA 24061

Contact this Certificate

Email Contact(s):
• Hannah Parks

Web Resource(s):
• HSI Certificate

Phone Number(s):
• *Hannah Parks*:
540/231-5586

[Certificate Overview](#)

[Admissions & Course Requirements](#)

Admission Requirements

Bachelor's degree in science or engineering with undergraduate grade point average that meets VT Graduate School requirements for admission (other undergraduate degrees that included appropriate coursework in mathematics and statistics may also qualify).

Course Requirements

1. ISE 5804 Fundamentals of Systems Engineering [context for HSI]
2. ISE 5154 Technology Enabled Human Performance [critical component of HSI]
3. ISE 5144 Life Cycle Measurement of System Performance [value impact of HSI]
4. ISE 5434 Economic Evaluation of Applied Technology [value impact of HSI]
 - All courses must have a grade of B or better.
 - Transfer credits are not permitted.



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Inclusion and Diversity IADC

Address:
Graduate Life Center, 155 Otey Street
Blacksburg, VA 24061

Contact this Certificate

Email Contact(s):
• Dr. Shernita Lee

Web Resource(s):
• Diversity and Inclusion

Phone Number(s):
• *Director's Office:*
540/231-6529

[Certificate Overview](#)[Admissions & Course Requirements](#)

Certificate Overview:

Description of Certificate:

The Graduate Certificate in Inclusion and Diversity extends graduate students' work in other disciplines by critically exploring the contemporary and historical foundations of diversity, equity, social justice, and inclusion within multiple fields. It explores biases, strategies for developing inclusive climates, fostering inclusion, and engagement to address diversity management, opportunities, and challenges. This certificate is for students seeking advanced skills, knowledge, and tools for effectively implementing formal and informal learning through pedagogy, programs, practices, and policies in a variety of settings. Students complete nine hours of coursework.

Target Audience:

This certificate program is open to all graduate students at Virginia Tech and external applicants who are seeking additional study in Inclusion and Diversity.

How to Apply:

Fill out the online application for participation in the certificate program.



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Inclusion and Diversity IADC

Address:
Graduate Life Center, 155 Otey Street
Blacksburg, VA 24061

Contact this Certificate

Email Contact(s):

- Dr. Shernita Lee

Web Resource(s):

- Diversity and Inclusion

Phone Number(s):

- *Director's Office:*
540/231-6529

[Certificate Overview](#)[Admissions & Course Requirements](#)

Admission Requirements:

Graduate students wishing to earn the graduate certificate in Inclusion and Diversity may be currently enrolled as masters or doctoral students in any discipline or major. Individuals must have satisfied all admissions requirements for their graduate degree and must remain in good academic standing. Graduate students submit the Graduate Certificate Application form to the Graduate School to formally enroll in the certificate program. Certificate credits may be used to meet degree requirements if they are appropriate for inclusion on the degree Plan of Study as determined by the student's faculty committee.

Individuals who wish to enroll at Virginia Tech to earn the Inclusion and Diversity graduate certificate without enrolling in a degree program may do so by submitting an online graduate certificate admission application. The Graduate School requires completion of a bachelor's degree from an accredited institution for admission.

When all certificate requirements have been satisfied, students must submit the Application for Degree or Certificate Conferral form to the Graduate School to authorize the issuing of the diploma and posting of the graduate certificate on the student's transcript.

Course Requirements:

Curriculum:

Graduate students must complete a minimum of nine graduate credits, six of which must be graded graduate credit with a grade of C- or better. Transfer credits are not permitted.

Required core course (3 credit hours):

- GRAD 5214 Diversity and Inclusion in a Global Society
-

Elective courses (6 credit hours) selected from an approved list of courses covering a range of inclusion and diversity topics. The two elective courses selected must be from two different groupings:

- Education - EDCO 5244, EDCI 5134, EDCI 5914, EDEL 5064, LS 5464, LS 5454
 - Identity Development - HIST 5224, HIST 5934, HD 5344, HD 5424, PSCI5384/WGS 5424, WGS 5124, SOC 5624, SOC 5714, WGS 5914, WGS 6004, SOC 5984/ RLCL 5004, SOC 5614, SOC 5624
 - Social -ENGL 5624, GIA 5274, SOC 5324, SOC 5414, SOC 5614, SOC 5034,UAP 5244, HD 5254, LS 5554, AFST 5364
-

Faculty:

The graduate certificate will be housed in the Graduate School and managed by the Dean for Graduate Education at Virginia Tech. All involved instructional faculty have doctoral degrees in related fields. The lead instructional faculty include:

Dr. Karen P. DePauw, Vice President and Dean for Graduate Education

Dr. Shernita Lee, Director of Recruitment, Diversity and Inclusion

Dr. Justin Grimes, Assistant Director of Recruitment, Diversity and Inclusion

Course Delivery Format:

Some courses are classroom-based, located on the Virginia Tech campuses in Blacksburg and the National Capital Region. Some courses are delivered via distance learning from Blacksburg to extended campus sites. Virginia Tech has advanced infrastructure and active support for online curricular delivery through Technology-enhanced Learning and Online Strategies (TLOS; <http://tlos.vt.edu>).

Resources:

Virginia Tech has the resources required to offer and sustain this certificate program. These include such resources as student support services (e.g., enrollment, help desk, library, etc.); faculty support services (e.g., copying, contracts, etc.); and general administration (e.g., budgeting and forecasting, facility maintenance, etc.).

Gainful Employment:

This certificate program will not come under gainful employment regulations.

Approved Elective Courses:

- EDCO 5244 *Counseling Diverse Populations* Examination and application of counseling strategies for special client populations including the exceptional; economically disadvantaged; culturally, racially and

ethnically different; those with different life styles. Emphasis on the range of human characteristics. 3 credit hours

- EDCI 5134 *Gender and Education* Introduction to gender in the context of education. This course is intended to raise awareness of how gender is implicated in teaching and learning in K-12 schooling and higher education. School policy as it relates to gender equality and sex education. Theoretical frameworks for gender analysis in education. 3 credit hours
- EDCI 5914 *Diversity & Multicultural Educ in the Teaching of Engl Language Learners* Issues in diversity and multicultural education applied to teaching, PK-12 and adult English language learners. Reflections and articulation of personal cultural perspectives. Principles for developing classrooms that foster equity and access to academic success for all students. Integration of interdisciplinary planning and teaching of core content lessons for English language learners 3 credit hours
- EDEL 5064 *Contemporary Issues in Special Education* Current issues in special education confronting school personnel and the effect of the standards and accountability movement on students with disabilities and special education programs. Impact of diversity, including ability, cultural and environmental diversity, on education programming. Models, practices and services in spec ed. 3 credit hours
- ENGL 5624 *Intercultural Communication* Examination of theoretical and practical issues pertaining to writing and designing for intercultural and/or international audiences. 3 credit hours
- GIA 5274 *Comparative Social Movements* This course will investigate the forms of public protest that occur all over the world, with special attention to activism in poor nations and to the recent emergence of transnational movements. Also examines why and when governments repress social movements. Explores movements that are grounded in collective identities based in class, race/ethnicity, gender, religion, and culture 3 credit hours
- HIST 5224 *Readings in African History* Variable topics readings course focusing on historiographical trends on particular themes in African history. 3 credit hours
- HIST 5934 *Gender in U.S. History* Theoretical approaches to understanding the role of gender in political, economic and social life and in popular culture. Survey of major themes and developments since the seventeenth century. Concentration on the development of biological and sociological explanations of gender differences and similarities, and on the evolution of gendered politics and work and family relationships. Emphasis given to class, race, ethnic differences and differences in sexual orientation. 3 credit hours
- HD 5254 *Epidemiology and Health Inequities* Social determinants of health through the life-course. Relationship of social injustice to public health. Interplay of major social factors such as poverty, race and gender to influence health domestically and globally. Application of social epidemiology to a range of health outcomes. Inform effective solutions to health inequities. 3 credit hours
- HD 5344 *Perspectives on Human Sexuality* Interdisciplinary historical consideration of writings, research, theory, and application of knowledge related to human sexuality. 3 credit hours
- HD 5424 *Life Span Human Development* Stages of individual development as they occur in the context of the family life course. Overview of current developmental theories. Impact of race, gender, and class on cultural views of developmental norms. 3 credit hours
-
- LS 5464 *Leadership in a Global Society* Identification and definition of leadership in formal and non-formal education settings, communities, & organizations. 3 credit hours
- LS 5454 *Leadership in Diverse Contexts* Identification and development of the personal and professional competencies required for effective leadership in an increasingly global, diverse and multicultural society. 3 credit hours
- LS 5554 *Leading Social Change* Theories, processes and strategies employed to facilitate social and organizational change. Roles of change agents with respect to institutional structures, adaption, innovation, and the progression of change. Theoretical perspectives of managing change as applied to the systems and structures associated with society and how organizations operate within these systems and structures. Problem solving, social entrepreneurship, organizational change, and contemporary issues. 3 credit hours
- PSCI 5384/ WGS5424 *Identity Migration and Place* Place-based identities and intersectional inequalities. Influence of these interrelated dimensions on the study of forced and voluntary migrations within and across national borders, and such discourses as home, belonging, nationhood, and citizenship. 3 credit hours
- SOC 5034 *Social Inequality* Perspectives on the sources and consequences of social inequality. Comparative analyses of the dynamic social construction of differentiation based on such markers as class, race, ethnicity, gender, age, religion, and sexual orientation, and the opportunities and constraints for life chances afforded by these processes. 3 credit hours
- SOC 5324 *Theorizing the African Diaspora* African diaspora theories and their historical foundations. Intersections of diaspora with race, gender, and national identities. Influence of theories of modernity,

postcolonial studies, transnationalism, and globalization on contemporary debates about the African diaspora. Application of diaspora theories to different geographic sites in the African diaspora including Europe, the Americas, and Africa. 3 credit hours

- SOC 5414 *Crime, Control, and Social Inequality* Dimensions of crime and systems of social control within a framework of social inequality; examines issues of social inequality, such as discrimination, relative to race and ethnicity, social class, and gender, in crime and systems of social control; international scope. 3 credit hours
- SOC 5614 *Racial and Ethnic Health Disparities* Racial and ethnic health disparities in the United States. Contributions of social factors to inequality in medical care and health for minorities. Current and potential impacts of health care policies on health disparities. 3 credit hours
- SOC 5624 *Women and Work* The analysis of the economic activities of women in contemporary society. The past and present relationship between women's domestic and market labor is examined, followed by an in-depth investigation of women's labor force experiences. Competing sociological explanations are examined, providing the basis for exploring occupational segregation, inequalities of outcomes and comparable worth. 3 credit hours
- SOC 5714 *Aging in Social Context* Social, political, and economic environments of aging in a variety of cultures with emphasis on aging problems in American society. Evaluation of the major social theories of aging, their roles in defining problems of the elderly, and focusing on current social policy. 3 credit hours
-
- SOC 5984/ RLCL 5004 *Foundation Appalachian Studies* Interdisciplinary study of Appalachia. Historiographical debates and theoretical frameworks that inform contemporary scholarship in Appalachian studies, especially as they relate to race, class, gender, and place. Regional history and demographics. Cultural representations of Appalachia. Current social, economic, and environmental issues. Application of theoretical and historical considerations to the construction of research projects. 3 credit hours
- UAP 5244 *Multicultural* Examines the growing ethnic and demographic diversity of urban United States. Stresses theories and techniques that can be used to bring about more inclusive planning and public policies at all levels of government. 3 credit hours
- WGS 5124 *Gender, Bodies, and Technology* Intersections of gender, bodies, and technologies in multiple contexts and across disciplines. Technology in individual lives and the gendered discourses surrounding bodies and technologies. Feminist and queer theories of technoscience and the impact of technologies on gendered bodies. 3 credit hours



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Information Policy and Society PIPC

Address:
Political Science (0130) Major Williams Hall, Room 515 220 Stanger Street
Blacksburg, VA 24061

Contact this Certificate

Email Contact(s):

- General Contact
- Graduate Program Director

Web Resource(s):

- Website

Phone Number(s):

- *General Contact:* 540/231-6572
- *Graduate Program Director:* 540/231-8843

[Certificate Overview](#)

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Certificate Overview

This graduate certificate program in Information, Policy and Society is designed for non-degree-seeking students and graduate students at Virginia Tech who wish to demonstrate special competence in the study of Information, Policy, and Society. This certificate responds to an existing demand by degree-seeking and non-degree students studying on campus or through on-line courses. It will recognize courses that students complete that focus on developing a foundation in the politics and policy of information networks.

How to Apply:

Fill out the online application for participation in the certificate program.



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Information Policy and Society PIPC

Address:
Political Science (0130) Major Williams Hall, Room 515 220 Stanger Street
Blacksburg, VA 24061

Contact this Certificate

Email Contact(s):

- General Contact
- Graduate Program Director

Web Resource(s):

- Website

Phone Number(s):

- *General Contact:*
540/231-6572
- *Graduate Program Director:*
540/231-8843

[Certificate Overview](#)[Admissions & Course Requirements](#)

Admission Requirements

Applications for the Graduate Certificate in Information, Policy and Society will be considered from students enrolled in a graduate program at Virginia Tech and from non-degree and Commonwealth Campus students who have been permitted to take courses by the Graduate School. Certificates will be awarded upon application for the certificate and application for certificate conferral once course requirements have been completed.

Course Requirements

The certificate requires successful completion of a total of twelve credit hours, of which 9 credits are required courses and 3 are elective. Students need to receive a grade of B or better in each course to receive the certificate. Students will not be allowed to retake a course for a better grade if they receive below a B. All courses are for 3 credit hours. All students must complete:

- * PSCI 5214 Contemporary Political Theory
- * PSCI 5374 Electronic Governance
- * PSCI 5554 Culture, Politics & Society in Network Environments

In addition, students must complete at least 3 credit hours from the following:

- * PSCI 5354 Public Policy Analysis
- * PSCI 5454 Advanced Topics in Information Technology and Policy



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Information Systems Design ISDC

Address:
VT-MIT Program Northern Virginia Center 7054 Haycock Road, Suite 365
Falls Church, VA 22043

Contact this Certificate

Email Contact(s):

• MIT Email

Web Resource(s):

• MIT Website

• MIT Certificates Website

Phone Number(s):

• MIT Office:

703/538-8384

[Certificate Overview](#)

[Admissions & Course Requirements](#)

Graduate Certificate in Information Systems Design

In today's business environment, ad-hoc approaches to information systems development are not sufficient. Modern approaches to the development of information systems, such as structured systems development, relational database development, and object-oriented systems development, are required. The Business Information Systems module prepares the student to become a business information systems developer using both structured and object-oriented systems development approaches. It also prepares the student to be able to design and develop business information systems that use a relational database. In this module, the student studies the strategies and techniques for dealing with the inherent complexity in the development of information systems. System development topics include coverage of (1) business systems planning; (2) fact-finding and requirements analysis techniques; (3) information systems process modeling; (4) logical and physical design; (4) user interface design; (5) introduction to database management systems and their use in business. Database topics covered include (1) data modeling, (2) normalization, (3) SQL, (4) transaction management and concurrency control, (5) physical data organization, (6) query optimization, (7) database administration, (8) distributed databases, (9) data warehousing, (10) integrating databases with the web.

The problem of efficient data storage and retrieval is one half of one of the core problems in Information Technology. The other half of that problem is determining how to use that data to decide optimal paths in complex domains.

This set of three courses in the certification in Information Systems Design will provide students with the specialized knowledge required to attack this problem domain.

Target Audience and Time to Complete:

The target audience is Virginia Tech graduate students who are interested in adding expertise in information systems design to that gained in their current degree program. In addition, we also expect that a number of database professionals will pursue the certificate both for job knowledge and career enhancement. Those students will be admitted as non-degree seeking certificate students.

In most cases, time to completion will be two semesters. Degree-seeking students may take courses in conjunction with their regular course load. Students attending full-time can complete the certificate in a minimum of one academic year and a maximum of four academic years. Degree-seeking students attending part-time can complete the certificate in approximately two academic years and a maximum of three academic years.

Non-degree seeking, full-time students can complete the certificate in a minimum of one academic year (two semesters). Non-degree seeking, part-time students, taking one course per semester, can complete the certificate in two academic years (four semesters).

[Master of Information Technology \(MIT\) Program](#)

[MIT Graduate Certificates](#)

How to Apply:

Fill out the online application for participation in the certificate program.



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Information Systems Design ISDC

Address:
VT-MIT Program Northern Virginia Center 7054 Haycock Road, Suite 365
Falls Church, VA 22043

Contact this Certificate

Email Contact(s):
• MIT Email

Web Resource(s):
• MIT Website
• MIT Certificates Website

Phone Number(s):
• MIT Office:
703/538-8384

[Certificate Overview](#)[Admissions & Course Requirements](#)

Admissions Requirements for the Graduate Certificate Information Systems Design

Admission to the Graduate School and completing a Graduate Certificate Application are required for both degree- and non-degree seeking students.

Degree-seeking applicants: The Graduate School requires completion of a bachelor's degree from an accredited institution with a GPA of 3.0 or better for admission to Certificate Status. Applicants with an undergraduate GPA < 3.0 may qualify for Commonwealth Campus admission. Students pursuing a degree and a certificate simultaneously are classified within their degree program.

For students interested in pursuing both the Master's degree in MIT and the certificate in Information Technology Management no more than fifty percent of certificate courses will be included toward completion of the MIT degree.

Non-degree seeking applicants: A qualified person who wishes to enter Virginia Tech to obtain a graduate certificate, without being enrolled in a degree program, may apply for graduate admission to Graduate Certificate by completing the [certificate application](#).

Applicants must meet the following criteria:

- GPA of 3.0 for admission for the last half of the credits earned for the undergraduate (bachelors) degree*
- Official transcripts must be submitted
- Academic background meets the requirements of the admitting academic unit
- International Applicants must submit scores from the Test of English as a Foreign Language (TOEFL) or International English Language Testing System (IELTS). A minimum TOEFL score of 550 paper-based (PBT) or 80 internet-based test (iBT) is required for consideration of the application. On the iBT, sub-scores of at least 20 on each subject test (Listening, Speaking, Reading, and Writing) are required for admission. A minimum IELTS score of 6.5 is required for admission. Some departments have higher TOEFL or IELTS score requirements than those set by the Graduate School.

[Admissions - MIT Graduate Certificates](#)

Course Requirements for the Graduate Certificate Information Systems Design

Number of Credit Hours:

A total of nine credit hours are required. Transfer credits are not permitted. Students must maintain a minimum GPA of 3.0 in the designated courses.

Required Courses:

ACIS 5504 Information Systems Design & Database Concepts: Introduction to design methodologies in information systems. Structured systems analysis and design methodologies are discussed. An introduction to database design methodologies is also included. Topics related to different database models and their implementation is discussed. Students are also required to design and implement information systems using appropriate computer software. (3H, 3C)

ACIS 5524 Advanced Database Management Systems: Relates database theories and practices to concepts from other areas such as programming languages, algorithms, data structures, and information systems. The relational, network, and hierarchical models are introduced. A major portion of the course deals with data manipulation languages for the relational model, design theory for relational databases, and query optimization. (3H, 3C)

ACIS 5534 Information System Development: Study of theoretical and pragmatic approaches to the development of computer-based information systems. The emphasis is on the management of the systems development process. Strategies for managing the complexity of information systems are explored. The building of logical and physical models of systems through traditional non-executable models and executable computer prototypes. Pre: ACIS 5504



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Information Technology Management ITMC

Address:
VT-MIT Program Northern Virginia Center 7054 Haycock Road, Suite
365
Falls Church, VA 22043

Contact this Certificate

Email Contact(s):

- MIT Email

Web Resource(s):

- MIT Website
- MIT Certificates Website

Phone Number(s):

- MIT Office:
703/538-8384

[Certificate Overview](#)[Admissions & Course Requirements](#)

Graduate Certificate in Information Technology Management

The IT arena presents a specialized set of management challenges. While there is some validity to the argument that management is an abstract skill which can be employed in any setting, the management problems which typically surface in large, complex IT projects, require a basic understanding of the underlying technologies. This certificate seeks to present a useful subset of these technologies.

Learning Outcomes: Students who complete this certificate will be able to

- Gain a managerial level understanding of the role of the leader in crafting corporate and business strategies where technology provides the basis for the firm's competitive advantage.
- Develop an entrepreneurial plan for a technology start-up business.
- Distinguish the use of various business tools and strategies in managing a tech-based organization.
- Demonstrate thorough grounding in the process of designing and implementing decision support systems in business.
- Use of common software tools to develop simple decision support system implementations.

Target Audience and Time to Complete:

The target audience is Virginia Tech graduate students who are interested in adding expertise in information technology management to that gained in their current degree program. In addition, we also expect that a number of professionals will pursue the certificate both for job knowledge and career enhancement. Those students will be admitted as non-degree seeking certificate students.

In most cases time to completion will be two semesters. Degree-seeking students may take courses in conjunction with their regular course load. Students attending full-time can complete the certificate in a minimum of one academic year and a maximum of four academic years. Degree-seeking students attending part-time can complete the certificate in approximately two academic years and a maximum of three academic years.

Non-degree seeking, full-time students can complete the certificate in a minimum of one academic year (two semesters). Non-degree seeking, part-time students, taking one course per semester, can complete the certificate in two academic years (four semesters).

[Master of Information Technology \(MIT\) Program](#)

[MIT Graduate Certificates](#)

How to Apply:

Fill out the online application for participation in the certificate program.



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Information Technology Management ITMC

Address:
VT-MIT Program Northern Virginia Center 7054 Haycock Road, Suite
365
Falls Church, VA 22043

Contact this Certificate

Email Contact(s):

- MIT Email

Web Resource(s):

- MIT Website

- MIT Certificates Website

Phone Number(s):

- MIT Office:

703/538-8384

[Certificate Overview](#)[Admissions & Course Requirements](#)

Admissions Requirements for the Graduate Certificate in Information Technology Management

Admission to the Graduate School and completing a Graduate Certificate Application are required for both degree- and non-degree seeking students.

Degree-seeking applicants: The Graduate School requires completion of a bachelor's degree from an accredited institution with a GPA of 3.0 or better for admission to Certificate Status. Applicants with an undergraduate GPA < 3.0 may qualify for Commonwealth Campus admission. Students pursuing a degree and a certificate simultaneously are classified within their degree program.

For students interested in pursuing both the Master's degree in MIT and the certificate in Information Technology Management no more than fifty percent of certificate courses will be included toward completion of the MIT degree.

Non-degree seeking applicants: A qualified person who wishes to enter Virginia Tech to obtain a graduate certificate, without being enrolled in a degree program, may apply for graduate admission to Graduate Certificate by completing the [certificate application](#).

Applicants must meet the following criteria:

- GPA of 3.0 for admission for the last half of the credits earned for the undergraduate (bachelors) degree*
- Official transcripts must be submitted
- Academic background meets the requirements of the admitting academic unit
- International Applicants must submit scores from the Test of English as a Foreign Language (TOEFL) or International English Language Testing System (IELTS). A minimum TOEFL score of 550 paper-based (PBT) or 80 internet-based test (iBT) is required for consideration of the application. On the iBT, sub-scores of at least 20 on each subject test (Listening, Speaking, Reading, and Writing) are required for admission. A minimum IELTS score of 6.5 is required for admission. Some departments have higher TOEFL or IELTS score requirements than those set by the Graduate School.

[Admissions - MIT Graduate Certificates](#)

Course Requirements for the Graduate Certificate in Information Technology Management

Number of Credit Hours:

A total of nine credit hours are required. Transfer credits are not permitted. Students must maintain a minimum GPA of 3.0 in the designated courses.

Required Courses:

BIT 5594 Web Applications and Electronic Commerce: An examination of the concepts, technologies, and applications of electronic commerce. Topics include the World Wide Web as a platform for electronic commerce; intranets; electronic data interchange; electronic banking and payment systems; security and firewalls; software agents; and the social, legal, and international issues of electronic commerce. Pre: ACIS 5514 or BIT 5474

BIT 5474 Computer-Based Decision Support Systems: This course explains the characteristics, use, and development of decision support systems (DSS) within the context of other business information systems. The process of designing and implementing decision support systems in business is discussed from both theoretical and practical standpoints. Students will learn various ways of measuring the success of DSS implementation as well as the difficulties associated with all such measures. Students will learn to use common software tools to develop simple DSS and will learn to use the Internet as a decision making and productivity tool. (3H, 3C)

MGT 5804 Strategic Leadership in Technology-based Organizations: This course focuses on the role of the leader in crafting corporate and business strategies where technology provides the basis for the firm's competitive advantage. (3H, 3C)



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Integrative STEM Education STMC

Address:
330 Sterrett Drive (0313), Public Safety Building, Suite 201
Blacksburg, VA 24061

Contact this Certificate

Email Contact(s):
• John G. Wells

Web Resource(s):
• PDF Form

Phone Number(s):
• Program Area Leader:
540/231-8471

[Certificate Overview](#)[Admissions & Course Requirements](#)

Certificate Overview

Spring of 2006 Virginia Tech (VT) became the first university in the US to offer an *Integrative STEM Education (I-STEM ED)* graduate program. The new I-STEM ED graduate degree options were designed to develop 21st century P-20 STEM educators, scholars, researchers, leaders, and change agents prepared as catalysts of change in the teaching, disseminating, and investigating of integrative technological/engineering (T/E) design based teaching and learning approaches to STEM education.

Our Graduate Certificate program focuses on investigating and applying new integrative, T/E design based learning approaches to STEM education that uniquely sets us apart from other STEM programs. Integrative STEM Education is wholly consistent with, and is an exemplar of, the recommendations of the seminal STEM education reform publications of the past two decades, including Science for All Americans, Benchmarks for Science Literacy, Principles and Standards for School Mathematics, National Science Education Standards, Standards for Technological Literacy, and Educating the Engineer of 2020.

The foundation of Integrative STEM Education is Technology and Engineering Education, which remains the disciplinary base – we are the **T** and **E** in STEM education. Building on its functional role as an integrator of content and practices across disciplines (ITEA, 2000, p 6-9), I-STEM ED provides the pedagogical tenet of integrative practices where technological/engineering design based learning is an instructional requirement. The essence of the new graduate program at Virginia Tech is conveyed in how Integrative STEM Education is operationally defined.

Integrative STEM Education is the use of "technological/engineering design based learning pedagogical approaches to *intentionally* teach content and practices of science and mathematics education inherent to the teaching of technology/engineering education content and practices. Integrative STEM Education is equally applicable at the natural intersections of learning within the continuum of content areas, educational environments, and academic levels" (Wells & Ernst, 2012/2015).

The term "integrative" implies an ongoing, dynamic, learner-centered process of teaching and learning distinct from "integrated" which connotes a static, completed teacher-centered process. Concepts critical in structuring this definition, and therefore the graduate program, were carefully selected, vetted over time, and employed to present a unique epistemological position. The leading concept is "technological/engineering design based" which is presented as the instructional requirement. It is immediately followed by "*intentionally*" which is italicized to emphasize its importance and refers to instructional design intent on targeting the teaching/learning of selected STEM content and practices - not only those of technology and engineering, but science and mathematics as well. This intent to teach is paramount and implies assessment of learning as a required component of the instructional design. It is central to the concept of integrative STEM education and what distinguishes the VT program

from all others. The last sentence of the definition clarifies that integrative STEM education operates along an educational continuum and at natural intersects of learning - it is mutually inclusive rather than exclusive. Specifically, it does not apply solely to the STEM subjects, is applicable in both formal and informal educational settings, and is appropriate at any academic level. And finally, when using the program acronym (I-STEM ED) the "I" is capitalized so as to convey the equal significance of "integrative" along-side the S.T.E.M. elements, physically connected to those elements with a hyphen, and "education" always follows the elements to emphasize this overarching goal (Wells, 2013).

Admissions Requirements

Bachelor's degree, 3.0+ GPA (min.) in final 60 Semester Hour (SH) of bachelor's degree program; Undergraduate Transcripts; Resume

Course Requirements

To be awarded the Graduate Certificate in Integrative STEM Education students must successfully complete the following 12 semester hours (SH) of coursework* offered by the Integrative STEM Education Program at Virginia Tech:

EDCI 5814: STEM Education Pedagogy (3 SH, fall semester only)

EDCI 5804: STEM Education Foundations (3 SH, fall semester only)

EDCI 5774: Readings in Technology Education (3 SH, fall & spring semester)

and one of the following:

EDCI 5854: Biotechnology Literacy by Design (3 SH, spring semester only)

EDCI 5824: STEM Education Trends and Issues (3 SH, spring semester only)

*Note: All coursework for this Graduate Certificate is available both on-campus and virtually via synchronous audio/video web-conferencing.

How to Apply:

Fill out the online application for participation in the certificate program.



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Integrative STEM Education STMC

Address:
330 Sterrett Drive (0313), Public Safety Building, Suite 201
Blacksburg, VA 24061

Contact this Certificate

Email Contact(s):

• John G. Wells

Web Resource(s):

• PDF Form

Phone Number(s):

• Program Area Leader:
540/231-8471

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Admission Requirements

---Bachelor's degree, 3.0+ GPA (min.) in final 60 Semester Hour (SH) of bachelor's degree program;
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Course Requirements

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Interdisciplinary Water and Health Science IWHC

Address:
402E HABBII, Virginia Tech, Blacksburg
Blacksburg, VA 24061

Contact this Certificate

Email Contact(s):

- Dr. Andrea Dietrich
- Dr. David Kuhn

Web Resource(s):

- Water INTERface official website
- Water INTERface Blog

Phone Number(s):

[Certificate Overview](#)

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Graduate Certificate In Interdisciplinary Water and Health Science

Clean water is a common topic discussed in many classrooms and research laboratories around this campus. Yet, the complexity of societal issues related to water shortages, hygiene, and quality, which influence water consumption and its role in human health, highlights the importance of increased interdisciplinary dialogue and problem-solving capabilities. The certificate reflects the acquisition of this interdisciplinary knowledge as related to “water and health.”

This certificate program is available to graduate students who are affiliated with the Water INTERface (WI) IGEP – at either the MS or PhD level. Students who successfully complete the 9 credits of WI IGEP coursework are eligible to apply to receive the certificate. Students may be affiliated with any department with WI IGEP mentorship agreement by a certificated WI IGEP Faculty (see website).

The IGEP is a non-degree granting program, thus students have a home department (i.e., that of their graduate advisor) with specific degree requirements. The water (WI IGEP) graduate certificate reflects the successful completion of the interdisciplinary coursework (including a 2 credit hour independent research project), which includes content related to four interdisciplinary research thematic areas:

- **Public Perception:** public perception of technological options and advancements for providing clean water resources (water treatment);
- **Risks:** risks (perceived or real) associated with contaminants and water-borne infectious diseases in private homes, public water systems, and commercial food processing facilities;
- **Chemistry:** role of water chemistry (e.g., mineral composition) in delivering functional qualities such as flavor and bioavailable nutrients;
- **Health:** role of water consumption in health, wellness, and mitigation of mineral deficiencies and diseases.

How to Apply:

Fill out the online application for participation in the certificate program.



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Interdisciplinary Water and Health Science IWHC

Address:
402E HABBI, Virginia Tech, Blacksburg
Blacksburg, VA 24061

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Email Contact(s):

- Dr. Andrea Dietrich
- Dr. David Kuhn

Web Resource(s):

- Water INTERface official website
- Water INTERface Blog

Phone Number(s):

[Certificate Overview](#)[Admissions & Course Requirements](#)

Admission Requirements: Graduate Certificate In Interdisciplinary Water and Health Science

Certificate applicants must have a baccalaureate degree or the equivalent of a US four-year degree from a regionally accredited institution, and must have been accepted (or are currently enrolled) in a degree-granting graduate program at Virginia Tech.

A minimum GPA of 3.0/4.0 is required to apply for the graduate certificate. Students who wish to apply to pursue the certificate should contact the program director, Dr. Susan Duncan and Dr. Andrea Dietrich (WI IGEP Program Directors and certificate coordinators). The applicant must have approval from WI IGEP Directors and agreement from a WI IGEP faculty mentor who are different from applicant's home department for the 5974 Independent Study. A formal request for admittance identifies and confirms the approval from applicant's WI IGEP research mentor (5974 Independent Study) and from applicant's thesis/dissertation advisor. Application for admittance includes the application for certificate ([application form](#)), letter of approval from thesis/dissertation advisor, letter of agreement from WI IGEP faculty mentor, CV, statement of interest, official transcript, GRE score report, and graduation certificates of baccalaureate degree or the equivalent of a US four-year degree from a regionally accredited institution (all materials can be submitted as electronic version).

Course Requirements: Graduate Certificate In Interdisciplinary Water and Health Science

Students will increase knowledge, advocacy, and comprehension of the four thematic areas (public perception, risk, chemistry, health) through the required certificate coursework, in addition to completing the graduate degree requirements of their home department. Students will explore critical thinking of the thematic areas in literature reviews and meeting research objectives in their course discussions, research activities, and dissertations. The IGEP certificate courses are as follows:

- Ethics course (complete one of the following):
 - Advanced Interdisciplinary Issues and Ethics in Water Resources (GEOG 5134) (3 credits)
 - Research Ethics in Agriculture and Life Sciences (ALS 5324) (3 credits)
 - Engineering Ethics and the Public (CEE 5804) (3 credits)
- Interdisciplinary Research (GRAD 5134) (3 credits)
- Water for Health Seminar (GRAD 5414) (1 credit)
- Independent Research Study (GRAD 5974) (2 credits)



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International Hospitality and Tourism Strategy IHTC

Address:
7054 Haycock Road
Falls Church, VA 22043

Contact this Certificate

Email Contact(s):

• Professor Mahmood Khan

Web Resource(s):

• Website

Phone Number(s):

• Mahmood Khan:
703/538-8486

[Certificate Overview](#)[Admissions & Course Requirements](#)

International Hospitality and Tourism Strategy Overview

Applications for the Graduate Certificate in International Hospitality and Tourism Strategy will be considered from students enrolled in a graduate degree program at Virginia Tech and from non-degree and Commonwealth Campus students who have undergraduate degrees.

Certificates will be awarded upon application for the certificate conferral once course requirements have been completed. The certificate has been designed so that both degree and non-degree seeking students from other majors may take the three courses within one semester and complete the certificate.

The purpose of this certificate is to provide middle managers in the Hospitality and Tourism industry with the tools and skills required to prepare them to engage in high-level strategic thinking and analysis on a global scale. In particular, this certificate will provide specific methods to utilize as part of their analysis and understanding of international markets and trends in HTM and ultimately allow certificate holders to compete for upper level managerial positions.

Upon completion students will be able to:

- Apply the concepts of international strategic management and competitive strategy to the hospitality industries.
- Analyze and develop strategies to address contemporary issues in the international business environment facing multinational service firms in the hospitality industry, including global strategy formulation and implementation; technology challenges; diversity in customers and employees; political and legal concerns; and effective organizational structures for long term survival.
- Analyze current macro dimensions of international marketing, e.g., culture, politics, and economics; international comparative marketing systems; international marketing management decisions; and international strategic planning and control and extrapolate these dimensions to the hospitality industry.

How to Apply:
Fill out the online application for participation in the certificate program.

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International Hospitality and Tourism Strategy IHTC

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7054 Haycock Road
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Contact this Certificate

Email Contact(s):

- Professor Mahmood Khan

Web Resource(s):

- Website

Phone Number(s):

- Mahmood Khan:
703/538-8486

[Certificate Overview](#)[Admissions & Course Requirements](#)

International Hospitality and Tourism Strategy Admission Requirements

Graduate certificates can be awarded to individuals who do not desire to work toward a degree as well as to students who are working on graduate degrees. Interested students must submit an official copy of their college transcript or diploma documenting receipt of a bachelor's degree from a regionally accredited college or university with an acceptable grade point average mailed to the Virginia Tech Graduate School as part of the application process. Please contact us for specific instructions on applying online. Students should meet with an academic adviser familiar with the classes on the list below and submit the application form to the HTM Graduate Administrator for Certificate Program Approval signature no less than six months prior to completion of coursework.

International Hospitality and Tourism Strategy Course Requirements

Number of Credit Hours: 9 credit hours. Transfer credits are not permitted.

Required Courses:

HTM 5534 Strategic Management and Competitive Strategy in the Hospitality Industries. To enable students to develop a comprehensive understanding of the concepts of strategic management and competitive strategy as applied to the hospitality industries. (3H, 3C)

HTM 5024 International Service Management. Overview of the contemporary issues in the international business environment facing multinational service firms in the hospitality industry. These issues include such topics as: global strategy formulation, and implementation; technology challenges; diversity in customers and employees; political and legal concerns; and effective organizational structures for long term survival. (3H, 3C)

Restricted Elective Courses:

Choose one of the following:

MGT 5784 International Management. This course focuses on the management challenges associated with the development of strategies and the management of organizations in business enterprises whose operations stretch across national boundaries. It will provide students with the knowledge, skills, and sensitivities that will help them manage more effectively in an international environment. (3H, 3C)

MKTG 5704 International Marketing Strategy. This course provides the background to make managerial marketing decisions at the international level. It is composed of four sections: macro dimensions of international marketing, e.g., culture, politics, and economics; international comparative marketing systems; international marketing management decisions;

and international strategic planning and control. (3H, 3C)



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International Research Abroad IRAC

Address:
Graduate School (MC 0325), Graduate Life Center, Virginia Tech, 155 Otey
ST NW
Blacksburg, VA 24061

Contact this Certificate

Email Contact(s):

- William Huckle
- Graduate School Admissions

Web Resource(s):

- Website

Phone Number(s):

- *William Huckle:*
540/231-5645
- *Graduate School Admissions:*
540/231-8636

[Certificate Overview](#)

[Admissions & Course Requirements](#)

Certificate Overview

In keeping with the global dimensions of Virginia Tech's research mission, many faculty and graduate students are engaged in research partnerships with scholars from numerous other countries. Students who engage in research while living in other countries can gain valuable disciplinary expertise as well as deep understanding of cultural dimensions of research that are essential for fruitful global endeavors. This certificate provides a means of recognizing students' efforts and accomplishments in gaining background knowledge required for successful international research collaborations and in conducting research abroad.

Eligible Students

- VT master's and doctoral students from multiple disciplines who are US citizens, including US permanent residents, seeking specialized research experiences in another country
- International VT master's and doctoral students from multiple disciplines who are seeking specialized research experiences in a country other than the US and countries where they have studied before (pending visa regulations)
- Students seeking degrees at universities in other countries who enroll at Virginia Tech as guest students for the purpose of gaining specialized research experience in the US

How to Apply:

Fill out the online application for participation in the certificate program.



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International Research Abroad IRAC

Address:
Graduate School (MC 0325), Graduate Life Center, Virginia Tech, 155 Otey
ST NW
Blacksburg, VA 24061

Contact this Certificate

Email Contact(s):

- William Huckle
- Graduate School Admissions

Web Resource(s):

- Website

Phone Number(s):

- *William Huckle:*
540/231-5645
- *Graduate School Admissions:*
540/231-8636

[Certificate Overview](#)

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Admission Requirements

- Meet Graduate School criteria: Completion of a bachelor's degree from an accredited institution with a GPA of 3.0 or better and English language proficiency
- Students enrolled in Virginia Tech degree programs must also meet the admission criteria for their programs

Course Requirements

The Graduate Certificate in International Research Abroad requires a minimum of 9 credits; these credits may be listed as part of the degree Plan of Study where permitted by program degree requirements.

- GRAD 5404, Research in International Contexts, 3 cr, graded A-F
- 3-cr elective focusing on knowledge and research expertise required to prepare for the international research abroad experience, must be graded a-F
- 3 or more cr of 5904, 5994, or 7994 based on research conducted abroad in collaboration with a scholar abroad, graded EQ by a VT faculty member who serves as instructor of record for the credits (each 3 cr requires a minimum of 6 weeks of full-time research work abroad)



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Internet and Network Technologies INTC

Address:
VT-MIT Program Northern Virginia Center 7054 Haycock Road, Suite 365
Falls Church, VA 22043

Contact this Certificate

Email Contact(s):

- MIT Email

Web Resource(s):

- MIT Website
- MIT Certificates Website

Phone Number(s):

- *MIT Office:*
703/538-8384

[Certificate Overview](#)[Admissions & Course Requirements](#)

Graduate Certificate in Internet and Network Technologies

Today we take for granted sending emails, streaming movies, and buying and selling products online. What started with just a few connected universities in the 1960s, the Internet now connects computers and networks across the world, allowing people and devices to communicate and share information through wired and wireless protocols. In fact, with the Internet of Things the internet is so pervasive in our lives that understanding how these networks work as well as how they can be used securely is essential knowledge in Information Technology. Internet and Network Technologies Certificate will provide students with the specialized knowledge required to understand this problem domain.

Target Audience and Time to Complete:

The target audience is Virginia Tech master's degree students who are interested in adding expertise in networking technologies to that gained in their current degree program.

However, we also expect that a number of corporate professionals will pursue the certification both for job knowledge and career enhancement. Those students will be admitted as non-degree seeking, MIT-Commonwealth students.

Non-degree seeking, full-time students can complete the certificate in a minimum of one calendar year (three semesters). Non-degree seeking, part-time students, taking one course per semester, can complete the certificate in two academic years (four semesters).

[Master of Information Technology \(MIT\) Program](#)

[MIT Graduate Certificates](#)

How to Apply:

Fill out the online application for participation in the certificate program.



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Internet and Network Technologies INTC

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VT-MIT Program Northern Virginia Center 7054 Haycock Road, Suite 365
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Contact this Certificate

Email Contact(s):

• MIT Email

Web Resource(s):

• MIT Website

• MIT Certificates Website

Phone Number(s):

• MIT Office:

703/538-8384

[Certificate Overview](#)[Admissions & Course Requirements](#)

Admission Requirements for the Graduate Certificate in Internet and Network Technologies

Admission to the Graduate School and completing a Graduate Certificate Application are required for both degree- and non-degree seeking students.

Degree-seeking applicants: The Graduate School requires completion of a bachelor's degree from an accredited institution with a GPA of 3.0 or better for admission to Certificate Status. Applicants with an undergraduate GPA < 3.0 may qualify for Commonwealth Campus admission. Students pursuing a degree and a certificate simultaneously are classified within their degree program.

For students interested in pursuing both the Master's degree in MIT and the certificate in Information Technology Management no more than fifty percent of certificate courses will be included toward completion of the MIT degree.

Non-degree seeking applicants: A qualified person who wishes to enter Virginia Tech to obtain a graduate certificate, without being enrolled in a degree program, may apply for graduate admission to Graduate Certificate by completing the [certificate application](#).

Applicants must meet the following criteria:

- GPA of 3.0 for admission for the last half of the credits earned for the undergraduate (bachelors) degree*
- Official transcripts must be submitted
- Academic background meets the requirements of the admitting academic unit
- International Applicants must submit scores from the Test of English as a Foreign Language (TOEFL) or International English Language Testing System (IELTS). A minimum TOEFL score of 550 paper-based (PBT) or 80 internet-based test (iBT) is required for consideration of the application. On the iBT, sub-scores of at least 20 on each subject test (Listening, Speaking, Reading, and Writing) are required for admission. A minimum IELTS score of 6.5 is required for admission. Some departments have higher TOEFL or IELTS score requirements than those set by the Graduate School.

[Admissions - MIT Graduate Certificates](#)

Course Requirements for the Graduate Certificate in Internet and Network Technologies

Number of Credit Hours:

A total of nine credit hours are required. Transfer credits are not permitted. Students must maintain a minimum GPA of 3.0 in the designated courses.

Required Courses:

ECE 5484 Fundamentals of Computer Systems: Fundamental principles and concepts of computer systems. Computer hardware; Boolean logic; number systems and representation; design and operation of digital logic; analysis of instruction set architectures and computer organization; and specification of data communication and networking standards Pre: Graduate Standing. (3H, 3C)

ECE 5485 Networks and Protocols: Fundamental principles and concepts of computer networks; application, transport, network, and data link protocols. Contemporary and emerging networks; Internet protocols. Principles of quality of service, network security, and network management. Pre: ECE 5484, CS 5044 (3H, 3C)

ECE 5480 Cybersecurity and the Internet of Things: Cybersecurity principles and technologies motivated by the evolving ecosystem of the Internet of Things (IoT): devices, operating systems, sensors, data storage, networking and communication protocols, and system services. IoT device and system security and privacy vulnerabilities,

analysis and attack mitigation techniques. Pre: ECE 5484 or CS 5044. (3H, 3C)

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Leadership for an Aging Society ASCC

Address:
230 Grove Lane (0555)
Blacksburg, VA 24061

Contact this Certificate

Email Contact(s):

Web Resource(s):

Phone Number(s):

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Overview of the Graduate Certificate in Leadership for an Aging Society

The Graduate Certificate in Leadership for an Aging Society is designed to teach students the fundamentals of the aging process and the leadership skills needed to manage an organization that serves older adults both ethically and effectively. Students will learn how to develop, implement, and assess organizational policy and lead teams that provide programs and services for older adults.

The program also covers a variety of topics related to serving in a leadership role in the elder care industry, such as the biological, psychological, and sociological impact of aging; ethical issues surrounding older adults and their families living in community or facility settings, including those of for-profit, nonprofit, and government organizations; and public policy development and approval processes at the local, state, and national levels.

This certificate will principally serve two broad audiences:

- Current professionals whose organizations specialize in assisting/caring for older adults in public or private settings; and
- Graduate students enrolled in a degree program related to aging (such as sociology, engineering, agriculture, nutrition, public administration, or human development).

Certificate recipients will be well prepared to lead and manage organizations that serve older adults in range of settings and levels.

How to Apply:

Fill out the [online application](#) for participation in the certificate program.



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Leadership for an Aging Society ASCC

Address:
230 Grove Lane (0555)
Blacksburg, VA 24061

Contact this Certificate

Email Contact(s):

Web Resource(s):

Phone Number(s):

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[Admissions & Course Requirements](#)

Admission Requirements

1. Bachelor's degree with a minimum GPA or 3.0 (4.0 scale)
2. TOEFL/IELTS score (if applicable)

Course Requirements

Total Number of Credit Hours

12 graduate credit hours

Core Courses – 12 credits

LAHS 5004: Organizational Leadership for an Aging Society (3 credits)

LAHS 5014: Ethics for an Aging Society (3 credits)

LAHS 5024: Public Policy for an Aging Society (3 credits)

LAHS 5034: Gerontology Leadership Capstone Project (3 credits)

Curriculum Requirements

Students will be required to complete coursework to develop knowledge and skills related to organizational leadership, ethical principles, and public policy for the aging services industry. Students will also be required to apply organizational leadership skills in a capstone project to develop, execute, and/or assess an elder care policy or program. Students will gain an understanding of the fundamental competencies needed to lead aging services organizations and manage teams that develop and implement policies and practices that address the care needs of older adults and their families.



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Learning Sciences LSCC

Address:

Blacksburg, VA 24061

Contact this Certificate

Email Contact(s):

• Kathy Cennamo

Web Resource(s):

• PDF Form

Phone Number(s):

• *Phone:*

540/231-9122

[Certificate Overview](#)[Admissions & Course Requirements](#)

Graduate Certificate in the Learning Sciences

The Certificate in the Learning Sciences provides an advanced understanding of learning in formal and informal environments, integrating perspectives from instructional design and technology, educational psychology, and social foundations. Students who complete the Graduate Certificate in the Learning Sciences will have demonstrated requisite knowledge and skills necessary to conceptualize, design, deliver, and measure effective learning. The Graduate Certificate in the Learning Sciences is appropriate for advanced graduate students considering careers such as higher education faculty, research scientists, educational administrators, funding agency program directors, and policy makers.

How to Apply:

Fill out the online application for participation in the certificate program.



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Learning Sciences LSCC

Address:

Blacksburg, VA 24061

Contact this Certificate

Email Contact(s):
• Kathy Cennamo

Web Resource(s):
• PDF Form

Phone Number(s):
• *Phone:*
540/231-9122

[Certificate Overview](#)[Admissions & Course Requirements](#)

Admission Requirements

To complete the Graduate Certificate in the Learning Sciences, students must be enrolled currently and in good standing in any graduate program at Virginia Tech. Students considering the Certificate should consult with faculty in one of the associated programs to plan their study to be consistent with prior experience, career goals, and certificate requirements.

Course Requirements

Students must take at least twelve credit hours in the options listed below. All students are required to enroll in EDIT 5234, Introduction to the Learning Sciences. Students will then choose one elective, equal to a three-credit-hour course, from *three* of the other *four* categories listed below, Cognition, Design, Social Foundations, and Technology. The order of these courses, including EDIT 5234, may be taken at the discretion of the student after consulting with his or her advisor.

a. Introductory Course (Required for Certificate)

EDIT 5234: Introduction to the Learning Sciences

b. Courses in Cognition

EDEP 5114: Learning and Cognition
EDEP 6114: Cognitive Processes and Educational Practice
EDEP 6224: Constructivism and Education
EDEP 6444: Motivation and Cognition

c. Courses in Design

EDIT 5164: Design for Learning*
EDIT 6334: Applied Theories of Learning*
EDIT 5224: Principles for Learning Message Design

d. Courses in Social Foundations

EDEP 5184: Sociocultural Influences on Learning and Instruction
EDCI 5174: Informal Learning for School Age Youth
EDCI 6024: The Analysis of Educational Concepts
EDCI 6044: Classroom Discourse

e. Courses in Technology

EDEP 6334: Multimedia Cognition
EDIT 5594: Topics in Learning Environment Design and Development
EDIT 5614: Digitally Mediated Learning
EDIT 5634: Interactive Learning Media Development

* Prior permission of instructor required for non-degree students outside Instructional Design and Technology or Educational Psychology

Application Process

When students decide to obtain the certificate, they should complete the Application - Certificate (Graduate Certificate Application). This form starts the process, designating the courses that will be taken for the certificate. Applicants should follow the directions on the form for returning it to the Graduate School. During the semester in which the certificate requirements are to be completed, students should complete and return the Application for

Degree or Certificate Conferral. Both of these forms are available from the "Forms" section of the Graduate School's home page <https://graduateschool.vt.edu/academics/what-you-need-to-graduate/forms.html>

Certificate Faculty

The following faculty members of the School of Education are affiliated with the Graduate Certificate in the Learning Sciences:

Dr. Katherine Cennamo
Dr. Peter Doolittle
Dr. Jim Garrison
Dr. Brett Jones
Dr. Barbara Locke
Dr. Ken Potter

For general inquiries regarding the certificate, please contact Katherine Cennamo (cennamo@vt.edu, 540-231-9122).



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Local Government Management LGMC

Address:
Center for Public Administration and Policy 104 Draper Road (0520) Virginia
Tech
Blacksburg, VA 24061

Contact this Certificate

Email Contact(s):
• Stephanie Davis

Web Resource(s):
• Program Website
• Program Website

Phone Number(s):
• Stephanie Davis:
804/980-5549
• Kelly Crist:
540/231-5133

[Certificate Overview](#)

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Certificate Overview

The Virginia Tech Center for Public Administration and Policy (CPAP), in partnership with the Virginia Local Government Management Association (VLGMA), has developed a graduate certificate program in local government management that helps to address the workforce development need for highly qualified public managers in local government. The central goal of the program is to offer graduate-level training in local government management that both prepares pre-career students for capable public service at the local level and enhances the capacities of existing local government employees who aspire to be town, city, or county managers or assistant/deputy managers.

The certificate program consists of four 3-credit hour courses, for a total of twelve hours of graduate coursework. Students are required to complete all four courses with a GPA of 3.0 or better in order to earn the certificate. Students are exposed to a full spectrum of local government issues, service delivery options, and management tools. The analysis of an actual local government case study is central to each classroom experience. Case studies are used within the courses to emphasize the relationship between the political and management worlds which all local government managers must understand and navigate in order to be successful. All courses are taught by experienced, highly qualified local government practitioners.

How to Apply:
Fill out the online application for participation in the certificate program.



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Local Government Management LGMC

Address:
Center for Public Administration and Policy 104 Draper Road (0520) Virginia
Tech
Blacksburg, VA 24061

Contact this Certificate

Email Contact(s):
• Stephanie Davis

Web Resource(s):
• Program Website
• Program Website

Phone Number(s):
• *Stephanie Davis:*
804/980-5549
• *Kelly Crist:*
540/231-5133

[Certificate Overview](#)

[Admissions & Course Requirements](#)

Admission Requirements

Non-degree candidates may apply for admission to the certificate program using the Virginia Tech Graduate School's online application system found at [Admissions](#). Interested students must submit an official copy of their college transcript documenting receipt of a bachelor's degree from a regionally accredited college or university with an acceptable grade point average mailed to the Virginia Tech Graduate School as part of the application process. Current MPA students should discuss their plans with the certificate director before applying for the certificate. If approved, up to six credit hours can be double-counted for the degree and the graduate certificate. Transfer credits are not permitted.

Course Requirements

Students are required to complete four courses with a GPA of 3.0 or better to earn the certificate.

Required Courses:

- PAPA 5044 Local Government and the Professional Manager
- PAPA 6354 Advanced Topics in Public Management: Human Resource, Financial, and Performance Management for Local Government Managers
- PAPA 6154 Advanced Topics in Public Organizations: The Context of Local Government Management in Virginia
- UAP/PAPA 5874 Local Economic Development Planning or UAP 5184 Planning Administration

On-line certificate

An on-line version of the Local Government Management certificate also is available. Designed for both a national audience and for Virginia residents who are unable to take synchronous classes, the on-line certificate has the same requirements, with course content and instructors from throughout the United States.



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Marriage and Family Therapy MAFC

Address:
7054 Haycock Road Suite 202
Falls Church, VA 22043

Contact this Certificate

Email Contact(s):

- Patricia Meneely,
Program Coordinator

Web Resource(s):

- Website

Phone Number(s):

- Program Coordinator's
Office:
703/538-8460

[Certificate Overview](#)[Admissions & Course Requirements](#)

Post-Master's Certificate Overview

Marriage and Family Therapy is a discipline for people who are interested in providing mental health services to individuals and families from a systems or relational perspective. This program prepares students to be family therapists who are well-grounded in systems theory and who are competent to diagnose and treat mental illness. Students have the opportunity to receive intensive supervision of their clinical work with a broad range of individuals, couples, and families at the Department's Center for Family Services. The post-master's certificate program is designed for students who already have a clinical master's degree. Students have the opportunity to take courses to prepare them for clinical membership in AAMFT and for professional licensure. While the program consists of a structured group of courses, each student will determine his or her own needs in order to supplement previous master's degree programs or to receive AAMFT Clinical Membership or licensure. The MFT post-master's certificate program encourages diversity. Members of minority groups are highly encouraged to apply.

How to Apply:

Fill out the online application for participation in the certificate program.



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Marriage and Family Therapy MAFC

Address:
7054 Haycock Road Suite 202
Falls Church, VA 22043

Contact this Certificate

Email Contact(s):

• Patricia Meneely,
Program Coordinator

Web Resource(s):

• Website

Phone Number(s):

• *Program Coordinator's
Office:*
703/538-8460

[Certificate Overview](#)[Admissions & Course Requirements](#)

Admission Requirements

Applicants for the Post-Master's Certificate in Marriage and Family Therapy Program must hold bachelor's and master's degrees from an accredited institution and present evidence of ability to do graduate level work, including a quality credit average of 3.0 on a 4.0 scale. Original transcripts, 3 letters of reference and a supplemental application are required in addition to the Virginia Tech on-line application. Potential students must also demonstrate that they have some professional or volunteer experience in a clinical setting.

Course Requirements

COURSEWORK

The program consists of advanced courses in marriage and family therapy and a supervised clinical practicum. A total of 21-24 post-master's credits must be earned for completion of the program. The program may be pursued on a part-time or full-time basis. Courses are offered during the day.

There are 5-6 academic courses (15-18 hours) required for the Post-Master's Certificate Program.

The required academic courses are:

HD 5404 Systems Theory and Family Therapy

HD 5434 Clinical Marriage and Family Therapy I (Structural and
Strategic Approaches

HD 5474 Professional Seminar in Marriage and Family Therapy (Ethics)

(this course may be waived if the student has taken a course in
professional ethics in his/her previous graduate work)

Choose three of the following courses depending on areas of interest:

HD 5724 Couples Therapy

HD 5344 Perspectives on Human Sexuality

HD 5424 Life-Span Human Development

HD 5444 Clinical Marriage and Family Therapy II (Constructivist
Approaches)

HD 5454 Clinical MFT III (Diagnosis and Treatment in the Family

Context)

HD 5464 Clinical Marriage and Family Therapy IV (Special Topics in

MFT)

HD 5744 Multicultural Family Therapy

Or any additional department courses available

Post-master's certificate in marriage and family therapy

in addition to the course requirements, 6.0 credit hours of HD 5964 MFT Practicum is required. The internship hours are served at the marriage and family therapy's Center for Family Services clinical facility in Falls Church, VA.

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Material Culture and Public Humanities MCHC

Address:
203 Draper Road
Blacksburg, VA 24061

Contact this Certificate

Email Contact(s):

- Aaron Ansell
- Michelle Moseley

Web Resource(s):

- Material Culture & Public Humanities

Phone Number(s):

- *Aaron Ansell:*
540/231-0491
- *Michelle Moseley:*
540/231-5547

[Certificate Overview](#)

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Graduate Certificate in Material Culture and Public Humanities

This is a cross-disciplinary graduate certificate comprised of 9 credits of key coursework in the MA Program in Material Culture and Public Humanities. These courses focus on material objects and their placement in theoretical, cultural, and historical perspectives, as well as public representations of a wide range humanities-based knowledge. As such, the Certificate prepares students for careers in museums, historical societies, and other cultural organizations.

The MCPH Certificate is geared both to VT graduates in other MA/PhD programs who wish to focus on themes of material culture and public humanities, and to scholars from outside the VT community who may wish to pursue continuing education as “Commonwealth Campus” students in this non-degree program.

Most of the courses on the Certificate curriculum are either already accessible to distance learners or can be adapted for distance learners upon conversation with the instructor.

See the MCPH Website (www.mcp.h liberalarts.vt.edu) for further information or contact one of the Graduate Directors, Dr. Aaron Ansell (aansell@vt.edu) or Dr. Michelle Moseley (mymc@vt.edu).

How to Apply:

Fill out the online application for participation in the certificate program.



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Material Culture and Public Humanities MCHC

Address:
203 Draper Road
Blacksburg, VA 24061

Contact this Certificate

Email Contact(s):

- Aaron Ansell
- Michelle Moseley

Web Resource(s):

- Material Culture & Public Humanities

Phone Number(s):

- *Aaron Ansell:*
540/231-0491
- *Michelle Moseley:*
540/231-5547

Certificate Overview

Admissions & Course Requirements

Admission Requirements

- Students already enrolled in other VT graduate (MA or PhD) degree programs may apply for the MCPH Certificate by filling out the [Graduate Certificate Application form](#) in consultation with one of the two co-directors of the MCPH program, Drs. Aaron Ansell (ansell@vt.edu) and Michelle Moseley (mymc@vt.edu).

Scholars from outside the VT community who wish to pursue an MCPH Certificate can do so by applying for graduate study via the Commonwealth Campus (see [link](#)). They will need to submit a transcript (unofficial is sufficient) or a copy of their diploma for the highest degree attained. (No graduate entrance exams are required.) For more information about the Commonwealth Campus see this [link](#).

All students seeking admission to the MCPH Certificate program should contact one of the Graduate Directors, Dr. Aaron Ansell (ansell@vt.edu) or Dr. Michelle Moseley (mymc@vt.edu).

Course Requirements

The certificate requires 9 credit hours, distributed as follows:

3 Credits Foundational Coursework, either

ART/HUM/RLCL 5104: Research Methods in Material Culture and Public Humanities (3H, 3C)

Investigation of methodologies with specific application to cultural objects situated in the public sphere

Or

ART/HUM/RLCL 5204: Research Methods in Material Culture and Public Humanities (3H,3C)

Topics cover steps for developing an installation, from analysis, archiving, to writing and interpretation for various audiences.

6 Credits Electives from the following courses

ART 5584: Topics in Material Culture (3H, 3C)

Advanced seminar. Provides a comprehensive examination of various periods and subjects of material culture through rotating topics. Topics indicated by timetable. May be repeated for credit for a maximum of 9 credits. Graduate standing required.

HUM/RLCL 5584: Topics in Public Humanities (3H, 3C)

Advanced seminar on topics in public humanities, ranging from an exploration of how various humanities disciplines relate to public issues and concerns, to a study of region, regionalism, and place in public humanities. May be repeated with different topic content for a maximum of 9 credits. Pre-requisite: Graduate Standing required.

HUM/RLCL: Material Culture and Humanities in the Public Sphere (3H, 3C)

Advanced seminar on material culture and humanities in the public sphere through an examination of humanistic approaches to civic spaces, applying critical turns to public debates.

RLCL 5124/ASPT 5124: Religion & Modernity in the West (3H, 3C)

A study of the relationship between religion and modernity in the West, with analysis of whether modern society is "disenchanted" or "secularized," or whether religion has remained a potent force in western society and thought. Through a survey of some of the major thinkers and themes of modern religious thought, we will consider the philosophical, economic, political, and legal aspects of the location of religion in the modern world. Pre: Graduate standing.

ART 5984: Exhibition, Design, and Display (3H, 3C)

Focus on the display and presentation of visual art, using local (including university) galleries and sites as venues for student-designed exhibitions. Provides experience in the public art arena, and practical knowledge about planning, designing and mounting exhibitions.

HIST 5424: Public History (3H, 3C)

Introduction to the theoretical, interpretive, controversial, and practical issues facing public historians. Focus on interpretations and specific issues surrounding the presentation of history in museum exhibits, documentary films, photographic collections, community history projects, the Internet, and a variety of other public venues.

With permission from a MCPH co-director, any other 5000 or 6000-level course in VT's Graduate Catalogue (including independent studies) can count toward the elective requirement.

See the MCPH Website (<https://www.mcph.liberalarts.vt.edu/course-descriptions/>) for further information about our courses.



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Metropolitan Studies METC

Address:
900 North Glebe Rd., Rm. 5-036
Arlington, VA 22203

Contact this Certificate

Email Contact(s):
• Kris Wernstedt

Web Resource(s):
• Website

Phone Number(s):
• *Myriam Lechuga*:
703/706-8111

[Certificate Overview](#)[Admissions & Course Requirements](#)

Certificate Overview

The Graduate Certificate in Metropolitan Studies is designed for those who are interested in acquiring a basic understanding of metropolitan development dynamics and the role of policy in influencing them. The certificate is part of the Urban Affairs and Planning program's overall mission to teach students how to understand, analyze, and influence the forces that shape the metropolitan built environment.

The target population includes current Virginia Tech and other graduate students in all fields, and others with undergraduate degrees who qualify for admission to the certificate program (including those who currently are not degree-seeking VT students).

How to Apply:

Fill out the online application for participation in the certificate program.



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Metropolitan Studies METC

Address:
900 North Glebe Rd., Rm. 5-036
Arlington, VA 22203

Contact this Certificate

Email Contact(s):
• Kris Wernstedt

Web Resource(s):
• Website

Phone Number(s):
• Myriam Lechuga:
703/706-8111

[Certificate Overview](#)

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Admission Requirements

Admission to the Certificate Program requires an application from a student in either 1) current graduate student status in good standing in Virginia Tech; or 2) non-degree certificate student status. A minimum undergraduate grade point average of 3.0 for this category is needed. Exceptions include achieving this minimum based on the last 60 semester hours of coursework or Commonwealth Campus admission if the GPA is above 2.75 but below 3.00. Official transcripts must be submitted. Application requirements are posted on Virginia Tech's Graduate School web site.

Course Requirements

The Certificate requires the completion of a minimum of 12 credit hours of graduate course work. To receive the Certificate, students must have a minimum grade point average of 3.0 for the courses taken.

Students seeking the Certificate who are not enrolled in the MURP degree program must complete at least six credit hours from among the following core certificate courses plus six credit hours in electives.

Core: Six credit hours from among:

UAP 5104: Urban & Regional Development Theory

UAP 5174: Planning Theory & History

UAP 5194: Urban Growth Management

UAP 5234: Urban Economy, Equity, & Society

Electives: Six credit hours from among other UAP courses including those not used for the core noted above, as approved by the faculty.

Students seeking the Certificate who are enrolled in the MURP degree program must complete the following two core certificate courses plus six credit hours in electives.

Core: Six core credit hours from:

UAP 5104: Urban & Regional Development Theory

UAP 5194: Urban Growth Management

Electives: Six credit hours from among other UAP courses not used for the core noted above and not appearing on the MURP plan of study, as approved by the faculty.

All courses used for the Certificate must be graded on an A-F basis. All courses also must be taken from Virginia Tech's Urban Affairs and Planning Program.



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Middle East Politics and Society MEPC

Address:
1021 Prince Street, School of Public and International Affairs, Virginia Tech
Alexandria Ctr
Alexandria, VA 22314

Contact this Certificate

Email Contact(s):

- Giselle Datz

Web Resource(s):

- GIA

Phone Number(s):

[Certificate Overview](#)

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Certificate Overview

This certificate provides students with the tools to interpret, analyze, and assess contemporary politics and society in the Middle East. The certificate focuses on the politics, society, and history of the peoples of North Africa, Southwestern Asia, Asia Minor, and the Arabian Peninsula, related borderlands and island groups, and including emigrant and immigrant groups. The certificate addresses the causes and consequences of conflict in the region, the impact of external interventions, including colonialism, and the drivers of political and social change. Having successfully completed the certificate students will be able to: 1) apply theories of cultural and social change to describe how culture and religion affects politics in the Middle East; 2) assess how external involvement have shaped the region's domestic and international politics; 3) analyze issues on comparative political theory pertaining to the methods of political representation, the status of women, minorities, and role of religion in Islamic polities; and 4) explain different approaches to conflict resolution as pertains to various political, economic, ethnic, and geopolitical struggles in the Middle East.

How to Apply:

Fill out the online application for participation in the certificate program.



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Middle East Politics and Society MEPC

Address:
1021 Prince Street, School of Public and International Affairs, Virginia Tech
Alexandria Ctr
Alexandria, VA 22314

Contact this Certificate

Email Contact(s):

- Giselle Datz

Web Resource(s):

- GIA

Phone Number(s):

[Certificate Overview](#)[Admissions & Course Requirements](#)

Admission Requirements

Applications for the Graduate Certificate in Middle East Politics and Society will be considered from students enrolled in a graduate degree program at Virginia Tech and from non-degree and Commonwealth Campus students who have been permitted to take courses by the Graduate School. Certificates will be awarded upon application for the certificate and application for certificate conferral once course requirements have been completed.

Non-degree seeking applicants

A person who wishes to enter Virginia Tech to obtain a graduate certificate, without being enrolled in a degree program, may apply for admission to Graduate Certificate status. Such applicants submit an Application for Admission and a Graduate Certificate Application, and

must meet the following criteria:

- GPA of 3.0 for the last half of the credits earned for the undergraduate degree,
- Submission of official transcripts,
- academic background appropriate for the Certificate, and
- International applicants must submit scores from the Test of English as a Foreign

Language (TOEFL) with a minimum of 550 paper-based (PBT) or 80 internet-based test (iBT), or the International English Language Testing System (IELTS) with a minimum score of 6.5.

Non-degree seeking applicants will be required to get permission of instructor before enrolling in individual classes.

Course Requirements

Total Number of Credit Hours: 9 credit hours. Transfer credits are not permitted.

Required courses—9 credits

Students will choose three courses:

- GIA 5314 Middle East Geopolitics (3 cr)
- GIA/PSCI 5614 (HIST 5544) Understanding the Israeli Palestinian Conflict (3 cr)
- ASPT 5134 Islamic Political Thought (3 cr)

• ASPT/HIST/RLCL 6124 (PSCI 6234) Pre-Modern Christian and Islamic Political Theory (3 cr)

Another 5000-level or 6000-level course subject to approval by the certificate candidate's advisor.



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Multidisciplinary Research in International Development IRDC

Address:
Global Education Office, 526 Prices Fork Road, Suite
131 (0378)
Blacksburg, VA 24061

Contact this Certificate

Email Contact(s):

- Caitlin Cook

Web Resource(s):

- website

Phone Number(s):

- *phone:*

540/231-5888

[Certificate Overview](#)[Admissions & Course Requirements](#)

Certificate Overview

The Graduate Certificate in Multidisciplinary Research in International Development allows graduate students already working towards a graduate degree to attain special recognition for work pertaining to international development. It is designed to encourage students to broaden their academic experiences while enabling them to better face international challenges. The program can offer interested students guidance in the choice of electives, course alternatives within the discipline, and thesis topics.

International development is a process of improving the lives of people in developing countries. It has three components: education and training, collaborative research, and technical assistance. Development work is multidisciplinary in nature, often involving members of several disciplines working together to define a common goal. No single discipline can provide a thorough understanding of the development process. The Graduate Certificate in Multidisciplinary Research in International Development promotes a multidisciplinary approach on the part of the student.

How to Apply:

Fill out the online application for participation in the certificate program.



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Multidisciplinary Research in International Development IRDC

Address:
Global Education Office, 526 Prices Fork Road, Suite
131 (0378)
Blacksburg, VA 24061

Contact this Certificate

Email Contact(s):

• Caitlin Cook

Web Resource(s):

• website

Phone Number(s):

• phone:

540/231-5888

[Certificate Overview](#)

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Admission Requirements

You must register no later than the last day to add courses of your last semester. Additionally, you must:

- be accepted as a graduate student in an established academic department;
- have at least one faculty member with experience in international development on your graduate committee;
- have your application signed by your major professor

course requirements and other requirements

- Take at least three courses from the [approved list](#) (contact the certificate administrator to discuss using courses that are not on the approved list)
- Ensure that one course is outside your department, and one course is outside your college
- Independent and special studies are accepted but must be relevant to international development and must be approved by the certificate advisory committee
- Write your thesis or major paper on a topic related to international development
- Make a presentation on your research prior to completion of the certificate
- The requirement for a course within your department may be fulfilled with an overseas research experience conducted in conjunction with completion of the course *GRAD 5404 Research in International Contexts* to meet the 9-credit minimum requirement

Application Process:

- Fill out the graduate certificate application
- Obtain the necessary signatures; return the original to the Graduate Life Center and submit a copy to the Global Education Office along with the completed Global Education certificate form and your program of study
- Contact the certificate administrator to arrange for a day/time/location to make your presentation
- Before graduation, submit an abstract of your thesis, dissertation, or major paper to the Global Education Office
- Complete the application for conferral of degree or certificate and return to the Graduate Life Center



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Natural Resources NATC

Address:
Virginia Tech Research Center - Arlington 900 N. Glebe Road
Arlington, VA 22203

Contact this Certificate

Email Contact(s):
• GCNR Information

Web Resource(s):
• Website

Phone Number(s):
• *Center for Leadership in
Global Sustainability:*
571/858-3338

[Certificate Overview](#)

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Graduate Certificate in Natural Resources (GCNR) Overview

This 12-credit graduate certificate is designed for students and professionals seeking graduate-level education and training in environmental and natural resource management. Students pursuing this certificate must complete 9 of the 12 credits with courses offered in the MNR program, including Conservation Ecology (NR 5724). The Graduate Certificate in Natural Resource Management is a good option for professionals seeking credentials in environmental and natural resource management.

Beyond the 9 credit hours that must be earned in courses offered through the MNR program, the remaining 3 credit hours may be earned in approved courses outside of the MNR program, including (but not limited to) courses offered as part of the Master of Landscape Architecture (MLA), Master of Urban and Regional Planning (MURP), and the Online Master of Arts in Political Science programs at Virginia Tech. Students must maintain a GPA of 3.0 or above for those 12 credit hours.

How to Apply:
Fill out the online application for participation in the certificate program.



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Natural Resources NATC

Address:
Virginia Tech Research Center - Arlington 900 N. Glebe Road
Arlington, VA 22203

Contact this Certificate

Email Contact(s):
• GCNR Information

Web Resource(s):
• Website

Phone Number(s):
• *Center for Leadership in
Global Sustainability:*
571/858-3338

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GCNR Admission Requirements

Students can apply for the GCNR as a degree-seeking student, non-degree-seeking student, or visiting student. If you are not currently a VT student or a graduate student at another institution (visiting student status), you must [apply for graduate admission](#) through the Virginia Tech Graduate School as a Graduate Certificate status applicant. Requirements for admission include:

- Completed undergraduate degree
- 2-3 Letters of Recommendation
- Current resume/ CV
- Personal goal statement
- Completed application
- No GRE required; TOEFL may be required for international students

GCNR Requirements

The GCNR can be completed in a single academic term or over the course of several semesters. Many students go on to complete a Master of Natural Resources degree. All NR courses are offered online for three credits unless otherwise noted.

Required coursework:

- NR 5724 Conservation Ecology (3 hours)
- NR Elective (3 hours)
- NR Elective (3 hours)
- NR Elective (3 hours)



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Naval Engineering NAVC

Address:
Aerospace and Ocean Engineering (MC 0203) Randolph Hall, RM 215 Virginia Tech 460 Old
Turner St.
Blacksburg, VA 24061

Contact this Certificate

Email Contact(s):

- Graduate Program Coordinator

Web Resource(s):

- Website

Phone Number(s):

- *General Assistance:* 540/231-3579

[Certificate Overview](#)

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Certificate Overview

Naval Engineering is defined as a field of study and expertise that includes all engineering and sciences as applied in the research, development, design, construction, operation, maintenance, and logistic support of surface and subsurface ships, craft, aircraft, and vehicles (manned and autonomous) used by the Navy for the nation's defense. It is inherently multidisciplinary involving all departments from the College of Engineering and departments from other colleges as well. This certificate program enables graduate students throughout the College of Engineering to better prepare for this critical profession. It is open to all graduate students in the College of Engineering including Distance Learning students.

How to Apply:

Fill out the online application for participation in the certificate program.



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540/231-3579

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Admission Requirements

Students must have:

- Registered no later than the last day to add courses for the semester in which they complete the last courses for the certificate,
- Submitted the application for the certificate to the Graduate School, which has been signed by one of the faculty members on the Graduate Certificate in Naval Engineering Oversight Committee,
- Attained a minimum GPA of 3.0 on a 4.0 scale in the designated courses, and
- Submitted the application for certificate conferral to the Graduate School.

Course Requirements

Required:

AOE	5324	Principles of Naval Engineering
AOE	5314	Marine and Naval Systems Engineering Design

Complete additional 6 units from the following list with a minimum grade of B- or better:

AOE	5304	Advanced Naval Architecture
AOE	5315&5316	Naval Ship Design
AOE	5074	Advanced Ship Structural Analysis
AOE	4344	Dynamics of High-Speed Marine Craft
AOE	5984G	Principles of Submarine Design



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Nonprofit and Nongovernmental Organization Management NNMC

Address:
Virginia Tech, National Capital Region 900 North
Glebe Road
Arlington , Virginia 22203

Contact this Certificate

Email Contact(s):

- Amanda Fawkes
- Leisha LaRiviere

Web Resource(s):

- VTO Website
- SPIA Website

Phone Number(s):

- *Amanda Fawkes:*
804/464-8355
- *Leisha LaRiviere:*
804/920-6084

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Certificate Overview

The School of Public and International Affairs' graduate certificate in Nonprofit and Nongovernmental Organization Management serves graduate students in the Washington Metro Region, Richmond, and Blacksburg and working professionals in both nonprofits/NGOs and the public sector. The certificate fosters the development of students by offering a streamlined curriculum focusing on the seamlessness between international and domestic environments, engaged pedagogy, reflexivity, and collaborative learning.

How to Apply:

Fill out the online application for participation in the certificate program.



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Nonprofit and Nongovernmental Organization Management NNMC

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Phone Number(s):

- *Amanda Fawkes:*
804/464-8355
- *Leisha LaRiviere:*
804/920-6084

[Certificate Overview](#)[Admissions & Course Requirements](#)

Admission Requirements

Admission and award requirements for the Nonprofit and Nongovernmental Organization Management certificate program are equivalent to the requirements for the Graduate School and the participating SPIA programs.

For persons not already enrolled in a Virginia Tech master's or doctoral program:

- Bachelor's Degree
- Graduate School application (Graduate Certificate in Nonprofit and NGO Management)
- Application Fee (see Graduate School for amount)
- Transcripts - undergraduate and other graduate degrees, if applicable.
- GRE scores are not required.
- Curriculum Vitae
- Letter describing your substantive interests and possible area of specialization
- International Students - also include TOEFL examination scores

For master's and doctoral students:

- be accepted as a graduate student in an established academic department
- have at least one faculty member from the School with experience in NPOs/NGOs on your graduate committee
- have your application signed by your major professor
- provide evidence of how you will integrate this certificate program into your overall plan of study

Certificate Award

In order to earn the graduate certificate in Nonprofit and Nongovernmental Organization Management, students must complete all certificate courses with a grade of "C-" or better and maintain a minimum GPA of 3.0 across the certificate courses.

Course Requirements

Students are required to take four out five of the following courses:

- **SPIA 5514 - Nongovernmental Organizations in International Development** (offered on Blacksburg campus and online) Roles of Nongovernmental Organizations (NGO) in international development. NGO interactions with local governments, community organizations, international governmental organizations, and private businesses. Tensions and collaborations between NGOs and other development actors.
- **SPIA 5544 - Public and Nonprofit Financial Management** (offered only online) Role of finance in the management of complex public, nonprofit, and nongovernmental organizations. Functions of financial management, including planning and budgeting, reporting, resource acquisition, and internal controls in the nonprofit context.
- **SPIA 5574 - Nonprofit Organization and Management** (offered on Blacksburg campus and online) Internal management for nonprofit and nongovernmental organization managers with emphasis on unique

cultural, social, political, and economic challenges facing nonprofit managers. Key management knowledge, processes, and systems skills for managers in nonprofit organizations and NGOs and the role of internal collaboration. Challenges facing domestic nonprofits compared to those found in nongovernmental organizations across the globe.

- **SPIA 5534 - Nonprofit Organization Leadership** (offered on Blacksburg campus and online) Methods of devising and implementing leadership strategies in the complex economic, cultural, social, and political contexts in which nonprofit and nongovernmental organizations operate. Theories, models, and tools for success, focusing on leadership accountability, ethos, and performance.
- **SPIA 5524 - Nonprofit Accountability and Evaluation** (offered only online) Societal role of the nonprofit sector. Why nonprofit organizations are held accountable, to whom they are accountable, and how organizations can satisfy accountability demands. Evaluation tools for accountability.



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Nuclear Engineering NEC

Address:
Mechanical Engineering Department 445 Signature Engineering Building (MC 0238) 635
Prices Fork Road
Blacksburg, VA 24061

Contact this Certificate

Email Contact(s):

- Mark Pierson
- Cathy Hill
- Allison Jones

Web Resource(s):

- Mechanical Engineering
- Nuclear Engineering

Phone Number(s):

- *Mark Pierson:*
540/231-9112
- *Cathy Hill:*
540/231-7460
- *Allison Jones:*
703/538-3790

[Certificate Overview](#)[Admissions & Course Requirements](#)

Certificate Overview

The primary purposes of the Nuclear Engineering Certificate are to (1) provide a purposeful, cohesive set of technical electives in nuclear engineering; and (2) facilitate networking among faculty, students, and employers in nuclear engineering applications. The certificate is useful in transitioning from a non-nuclear engineering-related job to a nuclear engineering-related job. The Nuclear Engineering Certificate will also make those who do not have a nuclear engineering degree more competitive in applying for engineering positions in the nuclear industry. The certificate provides a solid foundation in nuclear reactor physics, with additional specialization in reactor physics, nuclear fuel cycle, radiation measurements, reactor thermal hydraulics, nuclear materials, or nuclear power plant operations. The certificate requires completion of 9 credit hours of graduate course work.

How to Apply:

Fill out the online application for participation in the certificate program.



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Phone Number(s):

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540/231-9112
- *Cathy Hill:*
540/231-7460
- *Allison Jones:*
703/538-3790

Certificate Overview

Admissions & Course Requirements

Admission Requirements

Enrolled in the Graduate School through either a degree program or non-degree program. Applicants who have earned or will earn a B.S. degree in an engineering or science-related discipline are encouraged to have a 3.2 (4.0 scale) or higher GPA on their most recent 60 course credit hours during their undergraduate education. However, a minimum gpa of 2.8 (4.0 scale) will be considered for admission for Commonwealth Campus or Graduate Certificate applicants. No GRE test scores or recommendation letters are required.

Course Requirements

1. Complete a minimum of 9 credit-hours of nuclear engineering-related coursework through Virginia Tech – 3 credit-hours of required courses and 6 credit-hours of elective courses from the approved list below. The approved elective list will be updated each year. Only a maximum of 3 credit-hours total may be taken for NSEG 5974. Up to 6 credit-hours of NSEG 5984 may be taken if two different course titles are involved.

2. All courses must be taken for a letter grade with a grade of B- or better. Pass/Fail grades will only be permitted for the NSEG 5974 course. A final average GPA of 3.00 or better must be achieved in the 9 hours of coursework accepted for the certificate.

1. REQUIRED COURSE:

Course No. Title (Credit-hours)

NSEG 5114 Nuclear Engineering Fundamentals (3)*

** Completion of NSEG 3145 & 3146 at the undergraduate level will satisfy completion of this NSEG 5114 required course. However, another course from the Elective list below must replace it such that the student completes 9 graduate course credits total.*

2. ELECTIVE COURSES (select two):

Course No. Title (Credit-hours)

NSEG 5124 Nuclear Reactor Analysis (3)

NSEG 5134 Monte Carlo Methods for Particle Transport (3)

NSEG 5204 Nuclear Fuel Cycle (3)

NSEG 5214 Nuclear Power Plant Operations & Systems (3)

NSEG 5284 Nuclear Nonproliferation, Safeguards and Security (3)

MSE 5384G Advanced Nuclear Materials (3)

- NSEG 5424 Reactor Thermal Hydraulics (3)
- NSEG 5504 Radiation Effects on Metals and Alloys (3)
- NSEG 5514 Structural Materials Degradation in Nuclear Power Systems (3)
- NSEG 5604 Radiation Detection & Shielding (3)
- NSEG 5974 Independent Study (Nuclear Engineering) (3)**
- NSEG 5984 Special Study (Nuclear Engineering) (3)**
- NSEG 6124 Advanced Nuclear Reactor Analysis (3)
- NSEG 6334 Nuclear Reactor Safety Analysis (3)
- NSEG 6984 Advanced Special Study (Nuclear Engineering) (3)

*** A total of 3 hours maximum for NSEG 5974 or 6 hours maximum for NSEG 5984 (two different course titles) w/ approval of program coordinator*

Location

The Nuclear Engineering Program is located at:
Mechanical Engineering Department (MC 0238), 455 Goodwin Hall, 635 Prices Fork Road, Blacksburg, VA 24061

and at

National Capital Region
Virginia Tech Northern Virginia Center
7054 Haycock Road
Falls Church VA 22043



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Nuclear Science, Technology, and Policy NTPC

Address:
7054 Haycock Road
Falls Church, VA 22043

Contact this Certificate

Email Contact(s):
• Sonja Schmid

Web Resource(s):
• Department of Science, Technology, and Society
• Nuclear Engineering Program
• School of Public and International Affairs

Phone Number(s):
• Office:
703/538-8482

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Overview

The Nuclear Science, Technology, and Policy Graduate Certificate integrates policy and management with nuclear science and technology to prepare students from diverse educational backgrounds for careers managing and leading nuclear policy organizations across a spectrum of activity in safety, security, safeguards, and non-proliferation. The Certificate courses offer fundamental knowledge of concepts in nuclear science and technology that are relevant to policy issues, and also provide an introduction to topics in safety, security, and nonproliferation, which occupy the bulk of government concerns with nuclear issues. Finally, the Certificate will allow students to interact with policymakers in the field through briefings, simulations, and exercises at the Certificate's Northern Virginia locations and institutions, agencies, and other partners in Washington, DC. Available Spring 2019.

How to Apply:

Fill out the online application for participation in the certificate program.



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• Nuclear Engineering Program
• School of Public and International Affairs

Phone Number(s):
• Office:
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Admission Requirements

Admission to the Graduate School and completing a Graduate Certificate Application are required for all students. For both degree-seeking and non-degree-seeking students, the Graduate School requires completion of a bachelor's degree from an accredited institution with a GPA of 3.0 or better for admission to Certificate Status. Applicants with an undergraduate GPA < 3.0 may qualify for Commonwealth Campus admission. Students pursuing a degree and a certificate simultaneously are classified within their degree program. Certificate credits may be used to meet degree requirements if they are appropriate for inclusion on the degree Plan of Study. The faculty administering the Certificate will assist students with determining course selection.

Course Requirements

The total number of credit hours required is 12. The Certificate requires completing two dedicated ("core") courses: the anchor course, STS/SPIA/NSEG 5284, and a capstone course (offered as GRAD 5134 Interdisciplinary Research – this course will only count toward the Certificate when it is offered as the Nuclear Science and Technology Policy Certificate Capstone). In addition, each student selects one technical course, and one social sciences course ("electives"). Since some electives are offered under "advanced topics" course numbers, these courses can only count toward the certificate if they are offered on specific topics. We have provided a tentative list below ("related"); this list is not meant to be comprehensive. The certificate faculty will consider other related courses, existing and new ones, to count as electives toward the certificate. In all instances, the selection of elective courses needs to be approved by a student's advisor.

The core courses will be co-taught by faculty members from engineering/science and policy/STS. The two core courses explicitly target both technical and non-technical students.

The anchor course is designed to provide a broad overview of both technical and non-technical matters related to nuclear science, technology, and policy, and to introduce fundamental terms, categories, and processes, often in a hands-on manner.

The capstone course will include two main activities: 1) critical analysis of technical challenges and policy dilemmas in the nuclear fields; 2) engagement with specific case studies and current issues. For both activities, we will invite experts from various government and nonprofit organizations in the Washington DC Metro area to give seminars and to participate in the formation and evaluation of case studies. The students in the capstone will engage in a semester-long problem-based learning project that they will develop with their peers and instructors throughout the semester. They will apply the conceptual tools, theories, and methods

learned in the other certificate courses, and present a final report to a relevant agency or decision-maker.

List of courses

Core Courses

STS/NSEG/SPIA 5284 (anchor course), Nuclear Nonproliferation, Safeguards, and Security. Technical essentials, policy analysis, theoretical perspectives of nuclear energy and nuclear nonproliferation. Fundamentals of the nuclear fuel cycle, management of international safeguards, threat of nuclear terrorism, and challenges for global nuclear industry. Pre: Graduate standing (3H, 3C).

GRAD 5134 Interdisciplinary Research. Taught as the Capstone in Nuclear Science, Technology, and Policy. Seminar-style series of lectures, discussions, and active-learning exercises, with one semester-long problem-based learning assignment (depending on student numbers in two or more teams). This allows students to apply the tools acquired in the anchor course in interdisciplinary teams, with real-world relevance. The results of the project(s) will be presented to one or more stakeholders outside the university. Outside speakers will be recruited from industry, government agencies, national labs, community organizations, etc. Pre: Graduate standing (3H, 3C)

Electives, Technical Courses

NSEG 5114, Nuclear Engineering Fundamentals. A foundations course in nuclear engineering to prepare graduate students for all subsequent graduate work in the field of nuclear engineering. Topics include neutron physics, reactor theory and kinetics, basic reactor design and operation, and overall power plant operation. Pre: Graduate standing (3H, 3C)

NSEG 5124, Nuclear Reactor Analysis. Nuclear reactions and fission process. The fission chain reaction. Neutron diffusion and moderation. Introduction to reactor theory. One-speed diffusion model of a nuclear reactor. Neutron slowing and multigroup diffusion theory. Nuclear reactor kinetics. Introduction to reactor core physics design. Reactor physics analysis. Pre: 5114 (3H, 3C)

NSEG 5134, Applied Monte Carlo Methods for Particle Transport. This is a general course on the Monte Carlo Methods which uses fundamental particle transport concepts to demonstrate various methodologies and examine associated issues. The topics covered include: random processes; random number generation techniques and testing; fundamental formulation of Monte Carlo (FFMC); various sampling procedures; fundamentals of probability and statistics as needed for MC simulations; non-analog or variance reduction techniques; various tallying procedures; representation of physical models based on combinatorial geometry; solving integral formulations via MC; importance sampling and the use of importance function; use of MC for eigenvalue problems; MC methods in parallel and vector environments; and use of MC for simulation of various real-life problems. Pre: Graduate standing (3H, 3C)

NSEG 5204, Nuclear Fuel Cycle. Uranium nuclear fuel cycle: mining, conversion, enrichment, fuel manufacturing, in-core fuel management and refueling, spent fuel storage, reprocessing/recycling and final disposition as waste in a geologic repository. Introduction to nuclear safeguards and nonproliferation as applied to each step of fuel cycle. Pre: Graduate standing (3H, 3C)

NSEG 5214, Nuclear Power Plant Systems and Operations. Nuclear reactor startup and shutdown, reactivity control, casualty procedures, refueling, initial startup of new plants, standards and codes, ethics and integrity. Pre: 5114 (3H, 3C)

MSE 5384G, Advanced Nuclear Materials. Introduction to materials for nuclear applications with emphasis on fission reactors. Fundamental radiation effects on materials; material properties relevant to structural, moderator, reflector, blanket, coolant, control shielding and safety systems; processes such as nuclear fuel cycles, fuel enrichment and reprocessing, and related structural systems. Pre: Graduate standing (3H, 3C)

NSEG 5424, Reactor Thermal Hydraulics. Fundamental processes of heat generation and transport in nuclear reactors. Heat generation by fission and radiation interactions; spatial distribution of heat generation; heat transport by conduction and convection. Effects of boiling and critical heat flux. Fundamentals of reactor thermal and hydraulic design. Pre: 5114 (3H, 3C)

NSEG 5604, Radiation Detection and Shielding. Radioactive decay, interaction of charged particles and photons with matter, methods of radiation detection and radiation dosimetry, counting statistics, external radiation protection using time, distance and shielding. Pre: Graduate standing (3H, 3C)

NSEG 6124, Advanced Nuclear Reactor Analysis. Neutron transport theory: derivation and solution techniques of the neutron transport equation. Analytical solution methods; discrete ordinates method; spherical harmonics method. Integral form of the transport equation. Monte Carlo method. Introduction to neutron transport computer codes and their application in reactor core and shielding design. Pre: 5124 (3H, 3C)

NSEG 6334, Nuclear Reactor Safety Analysis. Hazards of nuclear reactors; analysis of hypothetical design basis accidents; engineered safeguards and safety design principles; nuclear criticality safety; reactor containment; reactor safety codes; and probabilistic risk assessment. Pre: 5114 (3H, 3C)

Electives, Social Sciences and Policy Courses

PAPA 5254, Homeland Security and the Terrorist Threat. A multidisciplinary introduction to the theory, strategy, decision-making, and doctrine of Homeland Security as practiced in the U.S. Describes the threat, nature of current global conflicts in which the U.S. is engaged, America's foreign and domestic policy responses to 9/11, and strategic and operational homeland security functions. Designed to promote subject matter understanding, simplification of issues, and consensus decision-making. Pre: Graduate standing (3H, 3C)

PAPA 5354, Homeland Security Response and Recovery. Multi-disciplinary policy course focused on emergency response and recovery following catastrophic manmade and natural disasters in the U.S. Emphasis on strategic and operational decision making; response models and strategies; the preparation, response and recovery roles and responsibilities of federal, state, and local jurisdictions; and federal policy alternatives to address the complex resource challenges of multi-jurisdictional response planning and operations execution. Designed to promote subject matter understanding, simplification of issues, and consensus decision-making. Pre: Graduate standing (3H, 3C)

GIA 5514 (PSCI 5514), Global Security. This course examines the changing nature of global security. It offers an introduction to the meaning of global security at a time of rapid change in international affairs. It examines the traditional sources of insecurity in the international system, the rising concerns and threats to global security from ethnic conflicts and failing states, and the emerging new security agenda arising from challenges to global stability including threats arising from poverty, discrimination, environmental degradation and the lack of human rights. This course seeks to understand the root causes of insecurity and the various challenges to international stability in the contemporary international system. Discussions include the policy implications of these security challenges, the mechanisms developed by the international community, and the response of states and other actors in the international system to meet these challenges today. Pre: GIA 5444 or PSCI 5444 or UAP 5264 (3H, 3C)

GIA 5664, Energy and Environmental Security (new course, under review). Assesses how energy and natural resources affect human conflict, security, and risk. Considers theories of scarcity and human ecology pertaining to causes of wars. Examines case studies of different natural resources to identify drivers of risk, resilience, and sustainability. Pre: Graduate standing (3H, 3C).

STS/SPIA 6554 Energy Policy: Historical and Contemporary Issues. Social-scientific perspectives in energy policy. National and international topics and controversies such as fossil fuel resources, climate change, energy security, and the debate over nuclear power. Comparison of international perspectives. Challenges involved with management and regulation of large technological systems, the politics of expertise at the intersection of global climate change and energy security, and the changing character of our global energy infrastructure. Pre: Graduate standing (3H, 3C).

STS/SPIA 6564, Risk in Contemporary Culture. Examines the phenomenon of risk from a variety of qualitative perspectives. Considers what constitutes a risk, and who decides what risks to take. Critically addresses notions of safety, reliability, and probability underlying risk assessment and risk management. Focuses on the role of expertise, trust, and communication in risk regulation. Discusses which democratic policy instruments facilitate stable, consensual decisions in contemporary societies. Pre: Graduate standing (3H, 3C).

PSCI 5464 (ASPT 5464), Critical Security Studies. Provides an overview of the critical study of security in world politics. Introduces alternative conceptualizations of security to the military-focused, state-centric security/strategic studies. Considers constructivist, post-structuralist and critical theoretic attempts to conceptualize the nature of security. Compares and contrasts these approaches with widely-accepted understandings of security in light of key debates in contemporary security studies. Pre: PSCI 5444 or GIA 5444 (3H, 3C)

PSCI 5474 (GIA 5474), Global Governance. Examination of the norms, institutions and practices developed by the international community to address systemic global governance problems: genocide, failed states, transnational corruption, displaced persons, AIDS, poverty. Role of United States in World community examined. Power of international organizations versus states. Capacity problems of both. Future of United Nations and global governance considered. Pre: Graduate Standing. (3H, 3C)

PSCI 5514 (GIA 5514) Global Security. Security examined as an essentially contested concept. Traditional national security and emergent global security discourses and agendas explained. Security institutions and organizations analyzed. Questions of power, identity and representation examined as factors delimiting security conceptions, practices and agendas. Pre: Graduate Standing. GIA 5444 or UAP 5264 or PSCI 5444 (3H, 3C)

PSCI 5524, U.S. Foreign Policy After September 11. Course offers a historical and analytical evaluation of U.S. foreign policy after this epochal change especially with regard to the war on terror, geopolitics in the Middle East, and relations with new global powers after the end of the Cold War. Pre: PSCI 5484 (3H, 3C)

Related Courses (course can count toward the Certificate only when taught on the specific topic listed after the colon)

PAPA 6254, Advanced Topics in Public Policy: Critical Infrastructure Protection and Resiliency. An introduction to the policy, strategy and practical application of critical infrastructure protection and resiliency from an all-hazards perspective. Describes the strategic context presented by the 21st century risk environment, as well as the challenges and opportunities associated with infrastructure -related public-private partnerships, information-sharing, risk analysis and prioritization, risk mitigation, performance metrics, and incident management. Students will be exposed to complex intergovernmental and public-private sector policymaking, operational planning and crisis management. Designed to promote subject matter understanding, critical analysis of issues and insight into senior leader decision making.

Includes a practical examination of stakeholder interaction and key subject matter areas through an interactive tabletop exercise and research paper assignment. Pre: Graduate standing (3H, 3C).

PAPA 6264, Advanced Topics in Policy Systems Management: Homeland Security and Prevention. Consideration of the critical integration of national security and homeland security policies and operational activities at the federal, state, and local levels to create management systems that function effectively in complex environments. This course examines the relationship between national security policies that manifest themselves in the international arena and homeland security policies that focus on U.S. domestic issues. Includes advanced study of information sharing, critical infrastructure, law enforcement, transportation systems, borders, and response and recovery operations. Also investigates the possibilities and limits for prevention and mitigation activities at all levels of government. Pre: Graduate standing (3H, 3C).

PAPA/STS 6664, Advanced Topics in Science and Technology Policy: Complexity, Emerging Policy, Doctrine and Strategy. Variable topics in science and technology policy. Includes advanced study of science, technology, and economy; science, technology, and power; strategies for research and development policy, public and private sector; transfer of technology; technological forecasting; government regulation and responses; science policy assumptions and challenges, specialist knowledge and expertise; state and academic knowledge production; issues of race, class, gender, and national identity in policy work. Pre: Graduate standing (3H, 3C).



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Politics and Policy Studies of Science and Technology PPSC

Address:
121 Lane Hall
Blacksburg, VA 24061

Contact this Certificate

Email Contact(s):
• Carol Sue Slusser

Web Resource(s):
• Website

Phone Number(s):
• Graduate and Undergraduate Coordinator:
540/231-0719

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Certificate Overview

The graduate certificate program in Politics and Policy Studies of Science and Technology targets three audiences: graduate students in other programs at Virginia Tech who would like to demonstrate additional competence in the politics and policies of STS, graduate students in contributing departments who would like to demonstrate special competence in the politics and policies of STS in their home discipline, and non-degree-seeking students who desire special competence in the politics and policies of STS for career advancement. In addition, mid-career professionals pursue this certificate if they are not particularly interested in another degree, however, they would like to be able to point to the completion of some shorter course of study. Students in this certificate program will critically assess science and technology policy. Students will be exposed to issues in bioethics in public policy, information technology, and politics.

How to Apply:

Fill out the online application for participation in the certificate program.



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Politics and Policy Studies of Science and Technology PPSC

Address:
121 Lane Hall
Blacksburg, VA 24061

Contact this Certificate

Email Contact(s):
• Carol Sue Slusser

Web Resource(s):
• Website

Phone Number(s):
• Graduate and Undergraduate Coordinator:
540/231-0719

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Admission Requirements

Graduate students accepted in any other graduate program at Virginia Tech would be admitted to the Politics and Policy Studies of Science and Technology graduate certificate program on the basis of their acceptance to their home department.

Recommendations for admission to the certificate program for non-degree-seeking students would be made by the STS Graduate Admissions Committee, based on transcripts, a writing sample, a statement of purpose, and the minimal requirements specified in the Graduate Catalogue for admission to the Graduate School. (These admissions criteria differ from our regular degree admissions in that they require neither the GRE nor letters of recommendation).

Course Requirements

Number of Credit Hours: 12 credit hours. Only 6 cr can be double-counted for this certificate and a graduate degree. Transfer credits are not permitted.

Required Courses (6 credit hours):

STS/SOC 5105: Social Studies of Science and Technology I

STS/PAPA 5614 Introduction to Science and Technology Policy

Restrictive Elective (6 credit hours):

STS 5424: Topics in Science and Technology Studies

STS 5444: Issues in Bioethics

STS/PAPA 6664: Advanced Topics in Science and Technology Policy

PSCI/GIA 5354: Public Policy Analysis

PSCI/GIA 5214: Contemporary Political Theory

SPIA/GIA 5454: Advanced Topics in Information Technology and Public Policy

SPIA/GIA 5555: Culture, Politics, and Society in a Networked Environment

UAP 5564: Information Technology, Society, and Public Policy



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Problem Solving for Leading Change PSLC

Address:
214 Litton Reaves Hall (0343)
Blacksburg, VA 24061

Contact this Certificate

Email Contact(s):
• Curtis Friedel

Web Resource(s):
• Problem Solving for Leading Change Certificate

Phone Number(s):
• *Curtis Friedel:*
540/231-8177

[Certificate Overview](#)[Admissions & Course Requirements](#)

Problem Solving for Leading Change

The purpose of this certificate is to examine how one's problem-solving style may influence how one solves problems, works in a team, leads change efforts, and acts as an agent of change in society. Solving complex problems and leading change can be a convoluted non-linear process and with many variables to consider. However, one key and often ignored variable is problem-solving style, which is how one prefers to solve problems. Problem-solving style indicates if a person is inherently more adaptive (making things better) or more innovative (making things different) when solving problems; which is completely independent of intelligence. Kirton's Adaption-Innovation theory is a common theme throughout the coursework, which provides explanation to how more adaptive and more innovative individuals may work together to lead change. Because we are all problem solvers, we are all leaders, and we are all agents of change.

Program Outcomes

This graduate certificate will complement Virginia Tech graduate students' academic education through the following learning outcomes:

- Evaluate the research literature regarding problem solving, problem-solving style, teamwork, and social change in light of contemporary theories.
- Examine the stages of problem solving, group development, and change management as they relate to each other.
- Propose practical solutions to identified societal problems by first identifying existing systems as an agent of change.

How to Apply:

Fill out the online application for participation in the certificate program.



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Problem Solving for Leading Change PSLC

Address:
214 Litton Reaves Hall (0343)
Blacksburg, VA 24061

Contact this Certificate

Email Contact(s):
• Curtis Friedel

Web Resource(s):
• Problem Solving for
Leading Change
Certificate

Phone Number(s):
• *Curtis Friedel*:
540/231-8177

[Certificate Overview](#)[Admissions & Course Requirements](#)

Admission Requirements

Admission to the Graduate School and completing a Graduate Certificate Application are required for all students. For both degree-seeking and non-degree-seeking students, the Graduate School requires completion of a bachelor's degree from an accredited institution with a GPA of 3.0 or better for admission to Certificate Status. Applicants with an undergraduate GPA < 3.0 may qualify for Commonwealth Campus admission. Students pursuing a degree and a certificate simultaneously are classified within their degree program. Up to 6 Certificate credits may be used to meet degree requirements if they are appropriate for inclusion on the degree Plan of Study.

Course Requirements

Course will be offered sequentially so that students may complete the Graduate Certificate in Problem Solving in four academic terms. For example:

- Fall - LDRS 5534: Cognition, Problem Solving, and Preferences for Change
- Spring - LDRS 5544: Leading Teams through Change
- Summer - LDRS 5554: Leading Social Change
- Fall - LDRS 5904: Project and Report

Information for Non-Degree Seeking Students

New students who are visiting graduate students, not seeking a degree, or associated with Commonwealth Campus, are asked to notify Dr. Curtis Friedel at cfriedel@vt.edu, after having applied to the Graduate School so that applications may be reviewed promptly.



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Public Health PHLC

Address:
262 Wallace Hall, 295 West Campus Drive
Blacksburg, VA 24061

Contact this Certificate

Email Contact(s):

• Kerry J. Redican, MPH, PhD, CHES

Web Resource(s):

• <http://publichealth.vt.edu>

Phone Number(s):

• 540-231-5743:
540/231-5743

[Certificate Overview](#)

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Certificate in Public Health (Online)

The Online graduate Certificate in Public Health (16 credits) includes the core courses in the Council on Education for Public Health (CEPH) accredited Master of Public Health (MPH) program offered by the Department of Population Health Sciences in the College of Veterinary Medicine. A Certificate in Public Health will be helpful to non-degree seeking students who have completed an undergraduate degree and want to demonstrate competence in public health. Also, the Certificate in Public Health will provide the content background for those professionals desiring to sit for the Certified in Public Health (CPH) exam.

How to Apply:

Fill out the online application for participation in the certificate program.



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Public Health PHLC

Address:
262 Wallace Hall, 295 West Campus Drive
Blacksburg, VA 24061

Contact this Certificate

Email Contact(s):

• Kerry J. Redican, MPH, PhD, CHES

Web Resource(s):

• <http://publichealth.vt.edu>

Phone Number(s):

• 540-231-5743:
540/231-5743

Certificate Overview

Admissions & Course Requirements

Certificate in Public Health Admission Requirements

Admission to the Graduate School and completing a Graduate Certificate Application are required for both degree- and non-degree seeking students.

Non-degree seeking applicants:

A qualified person who wishes to enter Virginia Tech to obtain a graduate certificate, without being enrolled in a degree program, may apply for graduate admission to Graduate Certificate status. Such applicants submit an Application for Admission and a Graduate Certificate Application http://graduateschool.vt.edu/content/dam/graduateschool_vt_edu/certificate_application.pdf, and must meet the following criteria:

- **GPA of 3.0 for admission for the last half of the credits earned for the undergraduate (bachelors) degree***
- **official transcripts must be submitted.**

Degree-seeking applicants:

The Graduate School requires completion of a bachelor's degree from an accredited institution with a GPA of 3.0 or better for admission to Certificate Status. Applicants with an undergraduate GPA < 3.0 may qualify for Commonwealth Campus admission. Students pursuing a degree and a certificate simultaneously are classified within their degree program. Certificate credits may be used to meet degree requirements if they are appropriate for inclusion on the degree Plan of Study.

- **academic background meets the requirements of the admitting academic unit.**
- **International applicants must submit scores from the Test of English as a Foreign Language (TOEFL) or the International English Language Testing System (IELTS). A minimum TOEFL score of 550 paper-based (PBT) or 80 internet-based test (iBT) is required for consideration of the application. On the iBT, subscores of at least 20 on each subtest (Listening, Speaking, Reading, and Writing) are required for admission. A minimum IELTS score of 6.5 is required for admission. Some departments have higher TOEFL or IELTS score requirements than those set by the Graduate School.**

Certificate in Public Health Requirements

Requirements: Completion the following 16 credits. Transfer credits are not permitted.

PHS 5004 – Foundations of Public Health (1 credit)

PHS 5014 – Environmental Health (3 credits)

PHS 5025 – Epidemiology and Quantitative Methods in Public Health I (3 credits)

PHS 5026 – Epidemiology and Quantitative Methods in Public Health II (3 credits)

PHS 5034 – Health Behavior and Health Education (3 credits)

PHS 5044 – Public Health Administration (3 credits)

(CIP 51.2201)



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Public History PHC

Address:
Department of History, 431 Major Williams Hall, 220 Stanger Street
Blacksburg, VA 24061

Contact this Certificate

Email Contact(s):

- Jessica Taylor
- Matthew Heaton

Web Resource(s):

Phone Number(s):

- *Department of History:*
540/231-5331

[Certificate Overview](#)

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Certificate Overview

The Graduate Certificate in Public History enables students to develop the analytical and interpretive tools of a graduate history education and to apply them in public practice. The certificate is earned with twelve credit hours. Six certificate credits can be used also to fulfill requirements for the Master's degree in History.

How to Apply:

Fill out the online application for participation in the certificate program.



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Public History PHC

Address:
Department of History, 431 Major Williams Hall, 220 Stanger Street
Blacksburg, VA 24061

Contact this Certificate

Email Contact(s):

- Jessica Taylor
- Matthew Heaton

Web Resource(s):

Phone Number(s):

- Department of History:
540/231-5331

[Certificate Overview](#)[Admissions & Course Requirements](#)

Admission Requirements

Students applying to the MA program in History should indicate an interest in public history and the Certificate in Public History as part of their application statement.

Students already admitted to graduate programs at Virginia Tech with an interest in pursuing the Graduate Certificate should send a letter of intent (no more than 500 words) addressed to the Graduate Committee, Department of History. In the letter applicants should explain their interest in public history and describe any experiences in a public history setting.

Admission to the certificate program requires good standing in a graduate program at Virginia Tech.

Course Requirements

The Graduate Certificate requires 12 credits of graduate level coursework in History, nine of which must be chosen from the department's public history course offerings and three from graduate level courses in history. The 12 credits for the Graduate Certificate are distributed as follows:

- HIST 5424: Public History (3 credits)
- HIST 5964: Field Study/Practicum (Internship) (3 credits)

At least one of the following public history courses:

- HIST 5434: Digital History Methods
- HIST 5444: Oral History
- HIST 5454: Topics in Public History

In addition, all students, including those not pursuing an MA in history, must complete a graduate level history course from the following list:

- HIST 5114: U.S. History to 1877
- HIST 5124: U.S. History since 1877
- HIST 5214/ASPT 5214: Topics in Global History
- HIST 5246: Readings in Latin American History
- HIST 5504: Modern European History

The Graduate Certificate in Public History requires 12 credits of graduate coursework in History, 9 of which must be chosen from the department's public history offerings. These include the public history graduate class and an additional offering on a public history methodology or topic. Additionally, students will complete a 3-credit, 120-hour internship with a historic site, museum, or institution of the student's choice, usually during the summer after the first year. For more information, see the requirements for the certificate on the history department's website, or contact the Director of Public History at JessicaTaylor@vt.edu.



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Public and Nonprofit Financial Management PNPC

Address:
2810 N. Parham Road, Suite 300
Henrico, Virginia 23294

Contact this Certificate

Email Contact(s):

- Amanda Fawkes
- Leisha LaRiviere

Web Resource(s):

- VT SPIA

Phone Number(s):

- *Amanda Fawkes:*
804/464-8355
- *Leisha LaRiviere:*
804/920-6084

[Certificate Overview](#)[Admissions & Course Requirements](#)

Certificate Overview

The graduate certificate in Public and Non-profit Financial Management is designed to develop students' and professional financial managers' understanding of the concepts and practice of financial management in the public and nonprofit sectors. The certificate integrates financial management perspectives from the Federal, State, Local and Nonprofit and Nongovernmental Organizations while synthesizing the concept of financial resiliency for organizations.

As public service organizations continue to face financial difficulties, financial mastery can no longer simply be the sole purview of accountants and other specially trained individuals. In the new public service landscape, financial competency is a must for all employees, and financial mastery is increasingly a pre-requisite for high-level positions in public service organizations. Available throughout the Commonwealth through virtual classroom technology, the Public and Non-Profit Financial Management certificate is designed for full-time students as well as part-time and working professional students. The shared format allows for a productive mix of viewpoints and experience levels, which enhances learning for all students. Students earning this certificate are prepared for a public service labor market that will demand financial literacy, whether they are pre-career students seeking first jobs or working professionals looking to broaden their horizons and for opportunities for advancement. Students are exposed to a full spectrum of financial management issues through both theoretical instruction and case studies. Classroom discussion and both group and individual assignments simulate real work scenarios and prepare students for real life application.

How to Apply: Fill out the online application for participation in the certificate program.

How to Apply:
Fill out the online application for participation in the certificate program.



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Public and Nonprofit Financial Management PNPC

Address:
2810 N. Parham Road, Suite 300
Henrico, Virginia 23294

Contact this Certificate

Email Contact(s):

- Amanda Fawkes
- Leisha LaRiviere

Web Resource(s):

- VT SPIA

Phone Number(s):

- *Amanda Fawkes:*
804/464-8355
- *Leisha LaRiviere:*
804/920-6084

[Certificate Overview](#)[Admissions & Course Requirements](#)

Admission Requirements

Non-degree candidates may apply for admission to graduate study using the Virginia Tech Graduate School's online application system at [Admissions](#). Interested students must submit an official copy of their college transcript documenting receipt of a bachelor's degree from a regionally accredited college or university with an acceptable grade point average to the Virginia Tech Graduate School as part of the application process.

Degree and non-degree candidates must submit the Application for Graduate Certificate form to the Graduate School.

Course Requirements

All students must complete SPIA 5024 and at least three of the other four courses listed below for a total of 12 hours of graduate coursework. Students are required to complete four courses with a GPA of 3.0 or better in order to earn the certificate.

Required:

- SPIA 5024 Overview of Public and Nonprofit Financial Management

Three of the following:

- SPIA 5654 Capital and Debt Financial Management for Public and Nonprofit Organizations
- SPIA 5674 Financial Health of Public and Nonprofit Organizations
- SPIA 5544 Public and Nonprofit Financial Management
- SPIA 5654 Budgeting for Performance Management and Outcomes for Public and Nonprofit Organizations



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Race and Social Policy RSPC

Address:
564 McBryde Hall, 225 Stanger St
Blacksburg, VA 24061

Contact this Certificate

Email Contact(s):
• Wornie Reed

Web Resource(s):
• Website

Phone Number(s):
• *Wornie Reed*:
540/231-6107

[Certificate Overview](#)

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Certificate Overview

The Race and Social Policy Certificate Program is a 12-hour concentration, providing an opportunity for Master's and Ph.D. level graduate students to develop understanding of issues of race, ethnicity and culture, especially as they relate to public policy. The certificate program's practical value includes the enhancement of knowledge and analytical abilities regarding the intersection of race, ethnicity and social policy issues. The certificate is a credential that is applicable to a wide range of careers, including law, secondary and higher education, human resources, criminal justice, health care, housing, and welfare. The overarching aim of the program is to provide a coherent, interdisciplinary grounding in race and social policy scholarship and to create an intellectual community among faculty and graduate students sharing similar scholarly interests.

How to Apply:

Fill out the online application for participation in the certificate program.



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Race and Social Policy RSPC

Address:
564 McBryde Hall, 225 Stanger St
Blacksburg, VA 24061

Contact this Certificate

Email Contact(s):
• Wornie Reed

Web Resource(s):
• Website

Phone Number(s):
• Wornie Reed:
540/231-6107

[Certificate Overview](#)[Admissions & Course Requirements](#)

Admission Requirements

Graduate students accepted in any graduate program at Virginia Tech may be admitted to the Race and Social Policy certificate program. Decisions for admission to the certificate program for non-degree seeking students would be made by the Sociology Graduate Admissions Committee, based on transcripts, a writing sample, and a statement of purpose.

Course Requirements

RSP concentration students are required to complete AFST 5984: Survey of Race and Social Policy in the U.S. (3 credits), plus 9 additional credits in approved graduate-level (5000 and above) electives. In addition to the pre-approved courses listed below, other courses may be approved by the Director upon review of a course syllabus to ascertain that sufficient attention is given to issues of race and ethnicity in the respective courses. Students planning to take courses not included in the pre-approved list should consult the Director prior to enrolling to insure that the desired course will meet the criteria established.

RSP Concentration Courses

Course Name and Number	Credit Hours
A. Required Core Course	
AFST 5984, Special Study: Survey of Race and Social Policy in the U.S. (Offered every other year)	3
B. Elective Courses (9 hours)	
Africana Studies	
AFST 5314, Theories in Africana Studies	3
AFST 5354, Topics in Africana Studies	3
AFST 5434, History of Africana People	3
History	
HIST 5114, the U.S. to 1877	3
HIST 5684, the U.S. South	3
HIST 5914, Race & Slavery in Comparative Perspective	3

Human Development

HD 5634, Legislation and Policy in Human Development Sociology	3
SOC 5034, Social Inequity (Offered every other year)	3
SOC 5917, Aging in Social Context (Offered every other year)	3
SOC 5984, Race and Social Inequity (Offered every other year)	3
SOC 5414, Crime, Control and Social Inequity	3
SOC 6214, Race and Mental Health (Offered every other year)	3



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Religious Studies RSC

Address:
115 Major Williams Hall, Virginia Tech
Blacksburg, VA 24061-0227

Contact this Certificate

Email Contact(s):

- Prof. Matthew Gabriele

Web Resource(s):

- Website

Phone Number(s):

- *Department of Religion & Culture:*

540/231-6551

[Certificate Overview](#)[Admissions & Course Requirements](#)

Certificate Overview

The graduate certificate in Religious Studies serves the Commonwealth, including (but not limited to) currently-enrolled graduate students at Virginia Tech. These students have come from programs such as Material Culture and Public Humanities, ASPECT, Sociology (including Women and Gender Studies, as well as Africana Studies), Political Science, Philosophy, English, and History.

Graduate courses for this certificate emphasize questions of method and theory in the academic study of religion. As such, the certificate gives students a way to formalize their academic interest in this field of study and hold a credential that will enhance their ability to find teaching, research, and policy positions after graduation. In addition, non-degree-seeking students will enhance their understanding of religion for professional or personal reasons.

How to Apply:

Fill out the online application for participation in the certificate program.



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Religious Studies RSC

Address:
115 Major Williams Hall, Virginia Tech
Blacksburg, VA 24061-0227

Contact this Certificate

Email Contact(s):

- Prof. Matthew Gabriele

Web Resource(s):

- Website

Phone Number(s):

- Department of Religion & Culture:

540/231-6551

[Certificate Overview](#)[Admissions & Course Requirements](#)

Admission Requirements

Candidates for the certificate should possess an undergraduate degree and meet the admission requirements of the Graduate School. Commonwealth Campus students and students who have Dual Status are also eligible for admission.

Course Requirements

The certificate requires the completion of 9 credit hours. No transfer credits are permitted.

6 credits from among the following are required (all are 3H, 3C):

- RLCL 5124 (ASPT 5124) - Religion & Modernity in the West
- RLCL 5134 (ASPT 5134) - Islamic Political Thought
- RLCL 6024 (ASPT 6024) - Major Figures in Contemporary Religious Thought

3 credits of elective courses from among the following:

- The list above
- Another 5000-level or 6000-level course subject to approval by the certificate candidate's advisor.
 - (Please be sure to check current course listings for special studies in RLCL, as well as other departments offering courses in the academic study of religion)

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Remote Sensing RMSC

Address:
Cheatham Hall, RM 319, MC0324 310 West Campus Dr
Blacksburg, VA 24061

Contact this Certificate

Email Contact(s):

- Randolph H. Wynne
- Wayne A. Scales
- Valerie A. Thomas
- Joseph B. Baker

Web Resource(s):

- Remote Sensing IGEP

Phone Number(s):

- *Randolph H. Wynne:*
540/231-7811
- *Wayne A. Scales:*
540/231-5622
- *Valerie A. Thomas:*
540/231-0958
- *Joseph B. Baker:*
540/231-3355

[Certificate Overview](#)[Admissions & Course Requirements](#)

Overview

Remote sensing provides technical and methodological approaches to holistically study human activities that have an impact on the Earth's sometimes poorly understood physical processes. Because remote sensing systems are often sensitive to wavelengths outside the visible portion of the electromagnetic spectrum (e.g., the infrared and microwave) they allow us to expand our view and "see" the world in a different way. Objective, inter-calibrated, and synoptic data streams from a wide variety of sensors and platforms have become increasingly available since the dawn of the space age. For some systems, archives contain several decades of imagery portraying interactions between humans and the Earth's environment. While the information resulting from analysis of these data is, by itself, policy relevant, only by combining the information available from remote sensing with the knowledge, approaches, and analytical tools of the social and natural sciences can complex issues at the interface of science and society be addressed. Further, remote sensing itself engenders a variety of social and policy questions, ranging from personal privacy to the social and cultural change that inevitably results from the wide adoption of transforming technologies.

How to Apply:

Fill out the online application for participation in the certificate program.



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Remote Sensing RMSC

Address:
Cheatham Hall, RM 319, MC0324 310 West Campus Dr
Blacksburg, VA 24061

Contact this Certificate

Email Contact(s):

- Randolph H. Wynne
- Wayne A. Scales
- Valerie A. Thomas
- Joseph B. Baker

Web Resource(s):

- Remote Sensing IGEP

Phone Number(s):

- *Randolph H. Wynne:*
540/231-7811
- *Wayne A. Scales:*
540/231-5622
- *Valerie A. Thomas:*
540/231-0958
- *Joseph B. Baker:*
540/231-3355

[Certificate Overview](#)[Admissions & Course Requirements](#)

Admission

Admission to the Graduate School and completing a Graduate Certificate Application are required for all students. For both degree-seeking and non-degree-seeking students, the Graduate School requires completion of a bachelor's degree from an accredited institution with a GPA of 3.0 or better for admission to Certificate Status. Applicants with an undergraduate GPA < 3.0 may qualify for Commonwealth Campus admission. Students pursuing a degree and a certificate simultaneously are classified within their degree program. Certificate credits may be used to meet degree requirements if they are appropriate for inclusion on the degree Plan of Study.

Course Requirements

The program requires 10 hours of graduate-level credit to obtain a Graduate Certificate in Remote Sensing from Virginia Tech. At least 2/3 of these courses must be graded A-F. Course credits from below 5000-level courses are not permitted. Four required courses (10 credit hours total) will be mandatory for all students in the program. These four mandatory courses will ensure that all students, regardless of disciplinary background, will be exposed to the same research approach. Further, all students will discuss common scientific and policy issues that have evolved from increasing natural and anthropogenic stresses on the earth system – stresses that are driving research and development in this field. When students finish the course requirements, the oversight committee chair will sign the Course Check Sheet. Students will need to submit an Application for Conferral of Certificate form to the Graduate School. Transfer credits are not permitted.

Courses:

Required Courses: (10 mandatory credit hours)

- Remote Sensing Engineering Principles (ECE 5194, I, 3H, 3C)
- Remote Sensing of Natural Resources (FOR 5254, II, 3H, 3C)*
- Seminar in GIS and Remote Sensing (FOR/GEOG 5104, II, P/F, 1H, 1C)
- Introduction to Science and Technology Policy (STS 5614, II, 3H, 3C)

Total credits for certificate = 10; No grade below "B" is accepted



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Research in Translational Medicine RTMC

Address:
Graduate School (MC 0325), Graduate Life Center, Virginia Tech, 155
Otey ST NW
Blacksburg, VA 24061

Contact this Certificate

Email Contact(s):

- William Huckle
- Graduate School Admissions

Web Resource(s):

- Website

Phone Number(s):

- *William Huckle:*
540/231-5645
- *Graduate School Admissions:*
540/231-8636

Certificate Overview

Admissions & Course Requirements

Certificate Overview

Translational medicine research encompasses 4 broad categories that include moving a scientific discovery into a clinical health application (T1-Bench to Bedside), a health application to evidence-based guidelines (T2-Bedside to Guidelines), guidelines to typical practice (T3-Guidelines to Delivery), and practice to sustainable policies (T4-Delivery to Policy). The progression across categories can be linear, asynchronous, and bi-directional. Thus, just as this process can move from bench to bedside, for example, it can also move from bedside to bench. Implicit in the translational process is the need for a multidisciplinary and team science approach.

This certificate responds to the National Institute of Health's Roadmap for Medical Research, launched in 2004 to promote biomedical research (<http://commonfund.nih.gov/aboutroadmap.aspx>) and to Virginia Tech's initiatives to expand educational and research programs in the health sciences. It provides the opportunity for graduate students to acquire specialized expertise in translational medicine research methods along with focal studies in their majors.

According to Bureau of Labor Statistics projections, career opportunities for medical scientists are expected to grow "much faster than average" (defined as an increase of 20% or more) from 2008 to 2018 (<http://www.bls.gov/oco/ocos309.htm#outlook>).

How to Apply:

Fill out the online application for participation in the certificate program.



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Research in Translational Medicine RTMC

Address:
Graduate School (MC 0325), Graduate Life Center, Virginia Tech, 155
Otey ST NW
Blacksburg, VA 24061

Contact this Certificate

Email Contact(s):

- William Huckle
- Graduate School Admissions

Web Resource(s):

- Website

Phone Number(s):

- *William Huckle:*
540/231-5645
- *Graduate School Admissions:*
540/231-8636

[Certificate Overview](#)[Admissions & Course Requirements](#)

Admission Requirements

- Admission to the Graduate School: Completion of a bachelor's degree from an accredited institution with a GPA of 3.0 or better and English language proficiency
- Admission to a graduate degree program
- Completion of the certificate application form

Course Requirements

The Graduate Certificate in Research in Translational Medicine requires completion of three modules focused on translational medicine course content, research methods and statistics, and research experience that links science to medical practice (24 cr). Course selection is based on individual students' background, research focus, and career goals. Students should work with their major professors and advisory committee members to identify appropriate courses and research experiences. Courses taken for the Certificate can also count toward the degree plan of study.

Module	Content	Minimum Number of Graduate Credits
1	Demonstration of subject matter expertise via courses relevant to translational medicine topics in student's major	9 cr (graded A-F unless only taught P/F)
2	Demonstration of competence in research methods and statistics related to translational medicine research via courses in research design, experimental procedures and other methods of data collection, and data analysis techniques	9 cr (graded A-F)
3	Demonstration of competence in conducting translational medicine research	6 cr of 5904, 5994, or 7994 (graded EQ)

Example Tracks

Biomedical Aspects	Biochemical/Molecular Biology/Genomics
	Biomedical Engineering and Bioinformatics

Behavioral & Social Aspects	Behavioral Science and Medicine
	Health Policy



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Science and Technology Studies STC

Address:
121 Lane Hall
Blacksburg, VA 24061

Contact this Certificate

Email Contact(s):
• Carol Sue Slusser

Web Resource(s):
• Website

Phone Number(s):
• *Graduate and Undergraduate Coordinator:*
540/231-0719

[Certificate Overview](#)[Admissions & Course Requirements](#)

Certificate Overview

The STS graduate certificate offers the opportunity to learn and develop competency in various aspects of the relations between science, technology, and society. It is intended to serve both existing graduate students in other programs at Virginia Tech and non-degree-seeking students interested in career advancement. For example, an STS certificate might help: a graduate student in Public Administration launch a career in administering a science-policy oriented NGO; a biology student who wants training in public engagement; or a graduate student in Philosophy who wishes to buttress a focus on the philosophy of science. Mid-career professionals who are not particularly interested in another degree may find the Certificate useful for building new competencies in areas such as technology analysis, science policy, or the public understanding of science.

How to Apply:

Fill out the online application for participation in the certificate program.



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Science and Technology Studies STC

Address:
121 Lane Hall
Blacksburg, VA 24061

Contact this Certificate

Email Contact(s):
• Carol Sue Slusser

Web Resource(s):
• Website

Phone Number(s):
• Graduate and Undergraduate
Coordinator:
540/231-0719

[Certificate Overview](#)[Admissions & Course Requirements](#)

Admission Requirements

Graduate students accepted in any other graduate program at Virginia Tech would be admitted to the STS graduate certificate program on the basis of their acceptance to their home department.

Recommendations for admission to the certificate program for non-degree-seeking students would be made by the STS Graduate Admissions Committee, based on transcripts, a writing sample, a statement of purpose, and the minimal requirements specified in the Graduate Catalogue for admission to the Graduate School. (These admissions criteria differ from our regular degree admissions in that they require neither the GRE nor letters of recommendation.)

Course Requirements

The certificate requires successful completion of twelve hours from the courses listed below, with grades of B+ or better. Only in extraordinary circumstances would substitutions for core courses be allowed. Any elective course substitution would require the approval of the Director of Graduate Studies.

Only six credits can be double-counted for this certificate and a graduate degree. Transfer credits are not permitted.

Core Courses (select three from the following list):

- STS/SOC 5105: Social Studies of Science and Technology I
- STS/SOC 5106: Social Studies of Science and Technology II
- STS/HIST 5205: History of Science
- STS/HIST 5206: History of Technology
- STS/PHIL 5305: Philosophy of Science and Technology I
- STS/PHIL 5306: Philosophy of Science and Technology II
- STS/PAPA 5614 Introduction to Science and Technology Policy

Elective Courses (select one from the following list):

- STS 5424: Topics in Science and Technology Studies
- STS 5444: Issues in Bioethics
- STS/HIST 5405: Development of Modern American Science
- STS/HIST 6224: Science, Technology, and the Enlightenment
- STS/HIST 6234: Advanced Topics in the History of Modern Science, Technology, and Medicine
- STS/PHIL 6314: History of Philosophy of Science
- STS/PHIL 6334: Advanced Topics in Philosophy of Science
- STS 6524: Critical Approaches to Science and Technology
- STS 6534: Cultural Studies of Science and Technology
- STS/PHIL 6514: Cognitive Studies in Science and Technology
- STS 6614: Advanced Topics in Technology Studies
- STS 6624: Advanced Topics in the Life Sciences and Medicine

- STS/PHIL 6634: Advanced Topics in Natural Philosophy
- STS/PAPA 6664: Advanced Topics in Science and Technology Policy
- STS/SOC 6824: Normative Structuring of Science and Technology
- STS/SOC 6834: Advanced Topics in Social Studies of Science and Technology
- PSCI/GIA 5354: Public Policy Analysis
- PSCI/GIA 5214: Contemporary Political Theory
- SPIA/GIA 5454: Advanced Topics in Information Technology and Public Policy
- SPIA/GIA 5555: Culture, Politics, and Society in a Networked Environment
- UAP 5564: Information Technology, Society, and Public Policy



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Security Studies PSOC

Address:
Political Science (0130) Major Williams Hall Room 515 220 Stanger Street
Blacksburg, VA 24061

Contact this Certificate

Email Contact(s):

- General Contact
- Graduate Program Director

Web Resource(s):

- Website

Phone Number(s):

- *General Contact:*
540/231-6572
- *Graduate Program Director:*
540/231-8843

[Certificate Overview](#)

[Admissions & Course Requirements](#)

Certificate Overview

This graduate certificate program in Security Studies is designed for non-degree-seeking students and graduate students at Virginia Tech who wish to demonstrate special competence in Security Studies. This certificate program responds to existing demand by degree-seeking and non-degree students, studying on campus or through on-line courses. It will recognize courses that concentrate in the area of security studies.

How to Apply:

Fill out the online application for participation in the certificate program.



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Security Studies PSOC

Address:
Political Science (0130) Major Williams Hall Room 515 220 Stanger Street
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Contact this Certificate

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- General Contact
- Graduate Program Director

Web Resource(s):

- Website

Phone Number(s):

- *General Contact:*
540/231-6572
- *Graduate Program Director:*
540/231-8843

[Certificate Overview](#)[Admissions & Course Requirements](#)

Admission Requirements

Applications for the Graduate Certificate in Security Studies will be considered from students enrolled in a graduate degree program at Virginia Tech and from non-degree and Commonwealth Campus students who have been permitted to take courses by the Graduate School. Certificates will be awarded upon application for the certificate and application for certificate conferral once course requirements have been completed.

Course Requirements

Completion of a total of twelve credit hours; 6 credits in required courses and 6 elective hours. Students must receive a grade of B or better in each course.

(Note: Students will not be allowed to retake a course for a better grade if they receive below a B.)

Required courses:

- PSCI 5444 - International Politics
- PSCI 5484 - American Foreign Policy

In addition, students must complete at least 6 credit hours from the following:

- PSCI 5324 - Executive Branch
- PSCI 5464 - Critical Security Studies
- PSCI 5474 - Global Governance
- PSCI 5514 - Global Security
- PSCI 5524 - U.S. Foreign Policy after 9/11
- PSCI 5534 - Regionalism and Political Development



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Software Development SWDC

Address:
VT-MIT Program Northern Virginia Center 7054 Haycock Road, Suite 365
Falls Church, VA 22043

Contact this Certificate

Email Contact(s):

• MIT Email

Web Resource(s):

• MIT Website

• MIT Certificates Website

Phone Number(s):

• MIT Office:

703/538-8384

[Certificate Overview](#)[Admissions & Course Requirements](#)

Graduate Certificate in Software Development

The purpose of this certificate is to provide students with a solid foundation in the tools and principles that underlie modern software development. The emphasis is on object-oriented software design and development, the most widely used approach for building complex software systems today. Beyond just learning to program, the certificate will prepare students to plan, manage, and assess software development projects and software quality. The emphasis in applications will be on distributed systems (e.g., web, cloud, mobile), which represents the most rapidly growing sector of software development.

For many years, every Bureau of Labor Statistics projection of employment growth has listed software engineering and software development as an area with great demand. Computer Science departments alone cannot graduate enough students to meet this demand. In many cases, students with non-CS undergraduate degrees can take advantage of informal and self-study resources to learn to program. However, in order to undertake a major software development effort, advanced training is critical. This certificate will be an efficient mechanism for students from a variety of backgrounds to gain the foundation they need to participate in and even lead significant software development projects.

Learning Outcomes: Students who complete this certificate will be able to

- Design and implement software systems using an object-oriented language such as Java.
- Identify and apply appropriate design patterns and software development processes to develop software systems.
- Learn languages and technologies needed to develop applications for modern mobile devices.
- Design and implement distributed software systems deployed over a web-based and cloud-based environment.

Target Audience and Time to Complete:

The target audience is Virginia Tech graduate students who are interested in adding expertise in software development to that gained in their current degree program. However, we also expect that a number of other professionals will pursue the certification both for job knowledge and career enhancement. Those students will be admitted as non-degree seeking, MIT-Commonwealth students.

In most cases time to completion will be two semesters. Degree-seeking students may take courses in conjunction with their regular course load. Students attending full-time can complete

the certificate in a minimum of one academic year and a maximum of four academic years. Degree-seeking students attending part-time can complete the certificate in approximately two academic years and a maximum of three academic years.

Non-degree seeking, full-time students can complete the certificate in a minimum of one academic year (two semesters). Non-degree seeking, part-time students, taking one course per semester, can complete the certificate in two academic years (four semesters).

[Master of Information Technology \(MIT\) Program](#)

[MIT Graduate Certificates](#)

How to Apply:

Fill out the online application for participation in the certificate program.



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Software Development SWDC

Address:
VT-MIT Program Northern Virginia Center 7054 Haycock Road, Suite 365
Falls Church, VA 22043

Contact this Certificate

Email Contact(s):
• MIT Email

Web Resource(s):
• MIT Website
• MIT Certificates Website

Phone Number(s):
• MIT Office:
703/538-8384

[Certificate Overview](#)[Admissions & Course Requirements](#)

Admission Requirements for the Graduate Certificate in Software Development

Admission to the Graduate School and completing a Graduate Certificate Application are required for both degree- and non-degree seeking students.

Degree-seeking applicants: The Graduate School requires completion of a bachelor's degree from an accredited institution with a GPA of 3.0 or better for admission to Certificate Status. Applicants with an undergraduate GPA < 3.0 may qualify for Commonwealth Campus admission. Students pursuing a degree and a certificate simultaneously are classified within their degree program.

For students interested in pursuing both the Master's degree in MIT and the certificate in Information Technology Management no more than fifty percent of certificate courses will be included toward completion of the MIT degree.

Non-degree seeking applicants: A qualified person who wishes to enter Virginia Tech to obtain a graduate certificate, without being enrolled in a degree program, may apply for graduate admission to Graduate Certificate by completing the [certificate application](#).

Applicants must meet the following criteria:

- GPA of 3.0 for admission for the last half of the credits earned for the undergraduate (bachelors) degree*
- Official transcripts must be submitted
- Academic background meets the requirements of the admitting academic unit
- International Applicants must submit scores from the Test of English as a Foreign Language (TOEFL) or International English Language Testing System (IELTS). A minimum TOEFL score of 550 paper-based (PBT) or 80 internet-based test (iBT) is required for consideration of the application. On the iBT, sub-scores of at least 20 on each subject test (Listening, Speaking, Reading, and Writing) are required for admission. A minimum IELTS score of 6.5 is required for admission. Some departments have higher TOEFL or IELTS score requirements than those set by the Graduate School.

[Admissions - MIT Graduate Certificates](#)

Curriculum Requirements for the Graduate Certificate in Software Development

Number of Credit Hours:

A total of twelve credit hours are required. Transfer credits are not permitted. Students must maintain a minimum GPA of 3.0 in the designated courses.

Required Courses:

CS 5044: Object-Oriented Programming with Java: Object-oriented programming concepts and the Java programming language. The application of design strategies, notations, and patterns related to object-oriented systems. Techniques and libraries for developing applications related to the World Wide Web. Credit will not be given for both 2704 and 5044. Not for Computer Science major or minor credit; not for graduate credit for CSA or INFS programs. Pre: Proficiency in a high-level programming language (e.g., FORTRAN, C, C++, or Java) equivalent to 1044 and prior course work, practical training, or work experience related to developing computer software and systems.

CS 5244: Web Application Development: Languages and technologies needed to develop modern data-centric web applications. Commonly used protocols and standards. Client-side technologies such as HTML, CSS, and JavaScript; server-side technologies such as Servlets and JSP; and database access with SQL. Principles and

technologies for web application architecture, electronic commerce, and web application security. Pre: CS 5044

CS 5704: Software Engineering: Study of the principles and tools applicable to the methodical construction and controlled evolution of complex software systems. Tools for all phases of the life cycle are presented; particular attention focuses on the design, testing, and maintenance phases. Attention to measurement models of the software process and product, which allow quantitative assessment of cost, reliability, and complexity of software systems. Pre: CS 5044

CS 5254: Mobile Application Development: Languages and technologies needed to develop applications for modern mobile devices. Mobile infrastructure and devices. Interactive graphical user interfaces for mobile devices. Protocols and standards for using mobile device features such as sensors, networking, location, camera, and audio. Mobile app architecture, performance consideration, and asynchronous programming. Principles and technologies for mobile security. Pre: CS 5044



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Technology Management TMC

Address:
VT ISE Department 250 Durham Hall (0118) Blacksburg, VA
Blacksburg, VA 24061

Contact this Certificate

Email Contact(s):
• Hannah Parks

Web Resource(s):
• TM Certificate

Phone Number(s):
• *Hannah Parks*:
540/231-5586

[Certificate Overview](#)[Admissions & Course Requirements](#)

Technology Management

A four-course academic program focused on the establishment, operation and management of enterprise capabilities for technological innovation – addressing the full spectrum of basic science (research), technology development (invention/intellectual property), product/service development, commercialization, deployment, maintenance, modernization, and retirement of performance enabling technologies.

How to Apply:

Fill out the online application for participation in the certificate program.



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Technology Management TMC

Address:
VT ISE Department 250 Durham Hall (0118) Blacksburg, VA
Blacksburg, VA 24061

Contact this Certificate

Email Contact(s):
• Hannah Parks

Web Resource(s):
• TM Certificate

Phone Number(s):
• *Hannah Parks*:
540/231-5586

[Certificate Overview](#)[Admissions & Course Requirements](#)

Admission Requirements

Bachelor's degree in science or engineering with undergraduate grade point average that meets VT Graduate School requirements for admission (other undergraduate degrees that included appropriate coursework in mathematics and statistics may also qualify).

Course Requirements

ISE 5164 Transfer and Application of Emerging Technology

ISE 5174 Engineering Program and Project Management

ISE 5154 Applied Human Factors Engineering

ISE 5134 Management Information Systems

All courses must have a grade of B or better. Transfer credits are not permitted.



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Traffic Control and Operations TCOC

Address:
Virginia Tech Civil & Environmental Engineering 750 Drillfield Dr. 200 Patton
Hall, MC: 0105
Blacksburg, VA 24061

Contact this Certificate

Email Contact(s):

• On-campus: Sarah H. Martin

Web Resource(s):

• Website

Phone Number(s):

• Blacksburg Campus:
540/231-6069

[Certificate Overview](#)

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Traffic Control and Operations - Certificate Overview

The Charles E. Via, Jr. Department of Civil and Environmental Engineering (CEE) coordinates the administration of seven graduate certificates. In the field of Advanced Transportation Systems, three certificates are available: Air Transportation Systems, Traffic Control and Operations, Transportation Systems Engineering. Related to Environmental Engineering, three certificates are available: Treatment Process Engineering, Water Quality Management, and Urban Hydrology and Stormwater Management. The certificate in Civil Infrastructure Systems encompasses a variety of CEE disciplines with emphasis in Infrastructure Engineering.

How to Apply:

Fill out the online application for participation in the certificate program.



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Traffic Control and Operations TCOC

Address:
Virginia Tech Civil & Environmental Engineering 750 Drillfield Dr. 200 Patton
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Contact this Certificate

Email Contact(s):

• On-campus: Sarah H. Martin

Web Resource(s):

• Website

Phone Number(s):

• Blacksburg Campus:
540/231-6069

Certificate Overview

Admissions & Course Requirements

Admission Requirements

The Graduate Certificate Program in CEE is open to on-campus (Blacksburg) students, full-time and part-time, who have been approved by the Virginia Tech Graduate School to take graduate coursework. Students interested in pursuing a certificate must first complete the following steps based on their current status:

Non-degree seeking VT students or individuals currently without a graduate status at VT

1. Complete the electronic Virginia Tech Graduate School "certificate seeking" application available at <https://applyto.graduateschool.vt.edu>. Applicants should apply before beginning the certificate program if they are already in a non-degree status at VT, but must apply no less than six months prior to completion of coursework. The application requires students to outline the classes they anticipate completing for the certificate (use the list of acceptable courses below). Students taking appropriate courses toward the certificate program prior to the application for certificate are not guaranteed admission to the certificate program. Applicants will be notified by letter if they are admitted into the certificate program.

2. If admitted, meet with a CEE academic advisor to confirm a final semester and coursework plan for completion of the certificate. See below for a list of contacts.

3. At the beginning of the semester for the final certificate course, students should submit the form called "Application for Degree or Certificate Conferral" through Hokie SPA. If students have taken different courses than outlined in the original application, they must complete the following form to receive approval for the changes: https://graduateschool.vt.edu/content/dam/graduateschool_vt_edu/GAAPforms/Application_Certificate.pdf

VT students already seeking a graduate degree

1. Students must complete the form called "Application for Certificate" and submit to the CEE department. The application form requires students to outline the classes they anticipate completing for the certificate. Applicants should apply before beginning the certificate program, but must apply no less than six months prior to completion of coursework. Students taking appropriate courses toward the certificate program prior to the application for certificate are not guaranteed admission to the certificate program. Applicants will be notified by letter if they are admitted into the certificate program.

2. If admitted, meet with a CEE academic advisor to confirm a final semester and coursework plan for completion of the certificate. See below for a list of contacts.

3. At the beginning of the semester for the final certificate course, students should submit the form called "Application for Degree or Certificate Conferral" through Hokie SPA. If students have taken different courses than outlined in the original application, they must complete the following form to receive approval for the

Course Requirements

Students who wish to complete the Graduate Certificate Program in CEE must:

1. Complete 12 hours from the course requirements listed below. Note that grades for certificate courses must be a C or higher and overall certificate GPA must be 3.0 or higher. No 4000 level classes may be used as an elective course.
2. CEE students and non-degree-seeking students must complete the Application for Degree or Certificate Conferral form online in Hokie SPA by the deadline for the semester you will complete your certificate program. You will find the ADCC form under the Graduate Student Degree Menu/Application for Degree section of Hokie SPA.
3. If the outlined courses for your planned certificate have changed from the time you originally applied for the certificate program, submit a new version of the form called "Graduate Certificate Application" to the CEE Department by the third week of class in the semester you plan to finish your certificate. The link to this form can be found here: https://graduateschool.vt.edu/content/dam/graduateschool_vt_edu/GAAPforms/Application_Certificate.pdf

Limitations (All students, independent of major)

1. A graduate student may only receive one graduate certificate within the completion of the degree requirements for a graduate degree within the CEE Department.
2. No hours can be transferred from institutions other than Virginia Tech.
3. No credits below 5000 level may be used to satisfy the requirements.
4. Course substitutions for those not on the lists below without prior approval by the CEE Graduate Director are prohibited.
5. Degree-seeking students may only count 6 of the 12 credit hours from the certificate course requirements toward their degree.
6. Non-degree-seeking students in the certificate program who are later admitted to degree-seeking status may count all 12 credit hours toward both their certificate requirements and degree requirements.

Departmental Contacts

Blacksburg Campus contacts :

CEE Graduate Student Coordinator

Sarah H. Martin, shmartin@vt.edu , (540) 231-6069

Director of International & Graduate Education:

Lindy Cranwell, lindycra@vt.edu, (540) 231-7296

Specific Courses for Certificates in Traffic Control and Operations

Traffic Control and Operations

Student must complete three of the following courses:

- CEE 5640: Highway Transportation Safety
- CEE 5604: Traffic Characteristics and Flow
- CEE 5634: Analysis and Planning of Mass Transit Systems
- CEE 5670: Applied Traffic Engineering Analysis
- CEE 5694: Traffic Signal Systems Operation and Control

The fourth course may be from the above list or those listed below:

- CEE 5624: Transportation Planning and Land Use
- CEE 5754: Pavement and Bridge Management Systems
- An Approved Technical Elective Course



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Transportation Systems Engineering TSEC

Address:
Virginia Tech Civil & Environmental Engineering 750 Drillfield Dr. 200
Patton Hall, MC: 0105
Blacksburg, VA 24061

Contact this Certificate

Email Contact(s):
• Blacksburg: Sarah H. Martin

Web Resource(s):
• Website

Phone Number(s):
• Blacksburg Campus: 540/231-6069

[Certificate Overview](#)

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Transportation Systems Engineering - Certificate Overview

The Charles E. Via, Jr. Department of Civil and Environmental Engineering (CEE) coordinates the administration of seven graduate certificates. In the field of Advanced Transportation Systems, three certificates are available: Air Transportation Systems, Traffic Control and Operations, Transportation Systems Engineering. Related to Environmental Engineering, three certificates are available: Treatment Process Engineering, Water Quality Management, and Urban Hydrology and Stormwater Management. The certificate in Civil Infrastructure Systems encompasses a variety of CEE disciplines with emphasis in Infrastructure Engineering.

How to Apply:
Fill out the online application for participation in the certificate program.



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Transportation Systems Engineering TSEC

Address:
Virginia Tech Civil & Environmental Engineering 750 Drillfield Dr. 200
Patton Hall, MC: 0105
Blacksburg, VA 24061

Contact this Certificate

Email Contact(s):
• Blacksburg: Sarah H.
Martin

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540/231-6069

[Certificate Overview](#)[Admissions & Course Requirements](#)

Admission Requirements

The Graduate Certificate Program in CEE is open to on-campus (Blacksburg) students, full-time and part-time, who have been approved by the Virginia Tech Graduate School to take graduate coursework. Students interested in pursuing a certificate must first complete the following steps based on their current status:

Non-degree seeking VT students or individuals currently without a graduate status at VT

1. Complete the electronic Virginia Tech Graduate School "certificate seeking" application available at <https://applyto.graduateschool.vt.edu>. Applicants should apply before beginning the certificate program if they are already in a non-degree status at VT, but must apply no less than six months prior to completion of coursework. The application requires students to outline the classes they anticipate completing for the certificate (use the list of acceptable courses below). Students taking appropriate courses toward the certificate program prior to the application for certificate are not guaranteed admission to the certificate program. Applicants will be notified by letter if they are admitted into the certificate program.

2. If admitted, meet with a CEE academic advisor to confirm a final semester and coursework plan for completion of the certificate. See below for a list of contacts.

3. At the beginning of the semester for the final certificate course, students should submit the form called "Application for Degree or Certificate Conferral" through Hokie SPA. If students have taken different courses than outlined in the original application, they must complete the following form to receive approval for the changes: https://graduateschool.vt.edu/content/dam/graduateschool_vt_edu/GAAPforms/Application_Certificate.pdf

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2. If admitted, meet with a CEE academic advisor to confirm a final semester and coursework plan for completion of the certificate. See below for a list of contacts.

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Course Requirements

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3. If the outlined courses for your planned certificate have changed from the time you originally applied for the certificate program, submit a new version of the form called "Graduate Certificate Application" to the CEE Department by the third week of class in the semester you plan to finish your certificate. The link to this form can be found here: https://graduateschool.vt.edu/content/dam/graduateschool_vt_edu/GAAPforms/Application_Certificate.pdf

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Director of International & Graduate Education:

Lindy Cranwell, lindycra@vt.edu, (540) 231-7296

Specific Courses for Certificates in Transportation Systems Engineering

Transportation Systems Engineering

Student must complete three of the following courses:

- CEE 5624: Transportation Planning and Land Use
- CEE 5634: Analysis and Planning of Mass Transit Systems
- CEE 5614: Analysis of Air Transportation Systems
- CEE 5604: Traffic Characteristics and Flow
- CEE 5670: Applied Traffic Engineering Analysis

The fourth course may be from the above list or those listed below:

- CEE 5640: Highway Transportation Safety
- CEE 5694: Traffic Signal Systems Operation and Control
- CEE 5600: Civil Infrastructure Systems Analysis
- CEE 5754: Pavement and Bridge Management Systems
- An Approved Technical Elective Course



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Treatment Process Engineering TPEC

Address:
Virginia Tech Civil & Environmental Engineering 750 Drillfield Dr. 200 Patton
Hall, MC: 0105
Blacksburg, VA 24061

Contact this Certificate

Email Contact(s):

• Blacksburg: Sarah H. Martin

Web Resource(s):

• Website

Phone Number(s):

• Blacksburg Campus:
540/231-6069

[Certificate Overview](#)

[Admissions & Course Requirements](#)

Treatment Process Engineering - Certificate Overview

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How to Apply:

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Treatment Process Engineering TPEC

Address:
Virginia Tech Civil & Environmental Engineering 750 Drillfield Dr. 200 Patton
Hall, MC: 0105
Blacksburg, VA 24061

Contact this Certificate

Email Contact(s):
• Blacksburg: Sarah H. Martin

Web Resource(s):
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Phone Number(s):
• Blacksburg Campus:
540/231-6069

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3. At the beginning of the semester for the final certificate course, students should submit the form called "Application for Degree or Certificate Conferral" through Hokie SPA. If students have taken different courses than outlined in the original application, they must complete the following form to receive approval for the changes: https://graduateschool.vt.edu/content/dam/graduateschool_vt_edu/GAAPforms/Application_Certificate.pdf

VT students already seeking a graduate degree

1. Students must complete the form called "Application for Certificate" and submit to the CEE department. The application form requires students to outline the classes they anticipate completing for the certificate. Applicants should apply before beginning the certificate program, but must apply no less than six months prior to completion of coursework. Students taking appropriate courses toward the certificate program prior to the application for certificate are not guaranteed admission to the certificate program. Applicants will be notified by letter if they are admitted into the certificate program.

2. If admitted, meet with a CEE academic advisor to confirm a final semester and coursework plan for completion of the certificate. See below for a list of contacts.

3. At the beginning of the semester for the final certificate course, students should submit the form called "Application for Degree or Certificate Conferral" through Hokie SPA. If students have taken different courses than

outlined in the original application, they must complete the following form to receive approval for the changes: https://graduateschool.vt.edu/content/dam/graduateschool_vt_edu/GAAPforms/Application_Certificate.pdf

Course Requirements

Students who wish to complete the Graduate Certificate Program in CEE must:

1. Complete 12 hours from the course requirements listed below. Note that grades for certificate courses must be a C or higher and overall certificate GPA must be 3.0 or higher. No 4000 level classes may be used as an elective course.
2. CEE students and non-degree-seeking students must complete the Application for Degree or Certificate Conferral form online in Hokie SPA by the deadline for the semester you will complete your certificate program. You will find the ADCC form under the Graduate Student Degree Menu/Application for Degree section of Hokie SPA.
3. If the outlined courses for your planned certificate have changed from the time you originally applied for the certificate program, submit a new version of the form called "Graduate Certificate Application" to the CEE Department by the third week of class in the semester you plan to finish your certificate. The link to this form can be found here: https://graduateschool.vt.edu/content/dam/graduateschool_vt_edu/GAAPforms/Application_Certificate.pdf

Limitations (All students, independent of major)

1. A graduate student may only receive one graduate certificate within the completion of the degree requirements for a graduate degree within the CEE Department.
2. No hours can be transferred from institutions other than Virginia Tech.
3. No credits below 5000 level may be used to satisfy the requirements.
4. Course substitutions for those not on the lists below without prior approval by the CEE Graduate Director are prohibited.
5. Degree-seeking students may only count 6 of the 12 credit hours from the certificate course requirements toward their degree.
6. Non-degree-seeking students in the certificate program who are later admitted to degree-seeking status may count all 12 credit hours toward both their certificate requirements and degree requirements.

Departmental Contacts

Blacksburg Campus contacts :

CEE Graduate Student Coordinator

Sarah H. Martin, shmartin@vt.edu , (540) 231-6069

Director of International & Graduate Education:

Lindy Cranwell, lindycra@vt.edu, (540) 231-7296

Specific Courses for Certificates in Treatment Process Engineering

Treatment Process Engineering

Students must complete four of the following courses:

- CEE 5104: Environmental Chemistry
- CEE 5794: Environmental Engineering Principles
- CEE 5125: Environmental Engineering Design I
- CEE 5126: Environmental Engineering Design II
- CEE 5174: Industrial Waste Treatment
- CEE 5194: Environmental Engineering Microbiology
- An Approved Technical Elective Course



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Urban Computing UCC

Address:
Torgersen Hall, Suite 3160
Blacksburg, VA 24061

Contact this Certificate

Email Contact(s):
• Wanawsha Hawrami

Web Resource(s):
• Certificate details

Phone Number(s):

[Certificate Overview](#)[Admissions & Course Requirements](#)

Certificate Overview

The Graduate Certificate in Urban Computing trains students in the latest methods in analyzing massive datasets to study key issues concerning urban populations. Students learn to apply methods in data analytics, computational modeling, and visualization. The certificate is open to degree- and non-degree seeking students. Students complete 12 hours of coursework for the certificate from an interdisciplinary selection, spanning Civil and Environmental Engineering, Computer Science, Electrical and Computer Engineering, Mathematics, Population Health Sciences, Sociology, Statistics, and Urban Affairs and Planning.

The Graduate Certificate in Urban Computing is available to all graduate students in the university. Graduate students can select courses from the list of approved courses. At least 2 of the courses must be from outside the student's home department. All courses are 3-hour credit unless otherwise noted in the Graduate Catalog. Transfer credits are not permitted. No hours can be below the 5000 level.

Details of course requirements and program checksheet are available at <https://dac.cs.vt.edu/academics/urban-computing/>.

How to Apply:
Fill out the online application for participation in the certificate program.



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Urban Computing UCC

Address:
Torgersen Hall, Suite 3160
Blacksburg, VA 24061

Contact this Certificate

Email Contact(s):

• Wanawsha Hawrami

Web Resource(s):

• Certificate details

Phone Number(s):

[Certificate Overview](#)[Admissions & Course Requirements](#)

Admission Requirements

Admission:

Admission to the Graduate School and completing a Graduate Certificate Application are required for both degree- and non-degree seeking students.

Degree-seeking applicants:

The Graduate School requires completion of a bachelor's degree from an accredited institution with a GPA of 3.0 or better for admission to Certificate Status. Applicants with an undergraduate GPA < 3.0 may qualify for Commonwealth Campus admission. Students pursuing a degree and a certificate simultaneously are classified within their degree program. Certificate credits may be used to meet degree requirements if they are appropriate for inclusion on the degree Plan of Study.

Non-degree seeking applicants:

A qualified person who wishes to enter Virginia Tech to obtain a graduate certificate, without being enrolled in a degree program, may apply for graduate admission to Graduate Certificate status. Such applicants submit an Application for Admission and a Graduate Certificate Application http://graduateschool.vt.edu/content/dam/graduateschool_vt_edu/certificate_application.pdf, and must meet the following criteria:

- GPA of 3.0 for admission for the last half of the credits earned for the undergraduate (bachelors) degree*
- Official transcripts must be submitted.
- Academic background meets the requirements of the admitting academic unit.
- International applicants must submit scores from the Test of English as a Foreign Language (TOEFL) or the International English Language Testing System (IELTS). A minimum TOEFL score of 550 paper-based (PBT) or 80 internet-based test (iBT) is required for consideration of the application. On the iBT, subscores of at least 20 on each subtest (Listening, Speaking, Reading, and Writing) are required for admission. A minimum IELTS score of 6.5 is required for admission. Some departments have higher TOEFL or IELTS score requirements than those set by the Graduate School.

Course Requirements

A. Required Core Courses: (6 credit hours minimum)

CS 5834 Introduction to Urban Computing

CS 5024 Ethics and Professionalism in Computer Science

B. Restricted Elective Courses: (6 credit hours minimum)

“Horizontal” (Data Science/Research Methods) Courses (Choose 1)

CS 5234 Advanced Parallel Computation

CS/MATH 5485 Numerical Analysis and Software I

CS/MATH 5486 Numerical Analysis and Software II

CS/STAT 5525 Data Analytics I

CS/STAT 5526 Data Analytics II

CS 5824/ECE 5424G: Advanced Machine Learning

CS 5764 Information Visualization

STAT 5444 Bayesian Statistics

STAT 5544 Spatial Statistics

“Verticals” (Urban Informatics/Applications) Courses (Choose 1)

CEE 5604 Traffic Characteristics and Flows

CEE 5634 Analysis & Planning of Mass Transit Systems

PHS/VM 5314 Infectious Disease Epidemiology

PHS 5354 Modeling Infectious Diseases

ECE 6304 Advanced Topics in Power

ECE 6334 Computational Methods in Power Engineering

SOC 5504 Population Processes and Policies

SOC 6504 The Sociology of Culture

**UAP 5114 Computer Applications in Urban Planning and Management

UAP 5234 Urban Economics and Policy

UAP 5604 Housing Planning and Policy Topics

UAP 5644 Transportation Systems Planning

** = students in the UAP department pursuing the certificate are advised, based on their background, to take UAP 5114 Computer Applications in Urban Planning and Management as a pre-requisite for CS 5834 Introduction to Urban Computing. Students should enroll in the section taught by either Wenwen Zhang or Theo Lim.



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Urban Hydrology and Stormwater Management UHSC

Address:
Virginia Tech Civil & Environmental Engineering 750 Drillfield
Dr. 200 Patton Hall, MC: 0105
Blacksburg, VA 24061

Contact this Certificate

Email Contact(s):
• Blacksburg: Sarah H. Martin

Web Resource(s):
• Website

Phone Number(s):
• Blacksburg Campus:
540/231-6069

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Urban Hydrology and Stormwater Management - Certificate Overview

The Charles E. Via, Jr. Department of Civil and Environmental Engineering (CEE) coordinates the administration of seven graduate certificates. In the field of Advanced Transportation Systems, three certificates are available: Air Transportation Systems, Traffic Control and Operations, Transportation Systems Engineering. Related to Environmental Engineering, three certificates are available: Treatment Process Engineering, Water Quality Management, and Urban Hydrology and Stormwater Management. The certificate in Civil Infrastructure Systems encompasses a variety of CEE disciplines with emphasis in Infrastructure Engineering.

How to Apply:
Fill out the online application for participation in the certificate program.



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Urban Hydrology and Stormwater Management UHSC

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Martin

Web Resource(s):
• Website

Phone Number(s):
• Blacksburg Campus:
540/231-6069

[Certificate Overview](#)[Admissions & Course Requirements](#)

Admission Requirements

The Graduate Certificate Program in CEE is open to on-campus (Blacksburg) students, full-time and part-time, who have been approved by the Virginia Tech Graduate School to take graduate coursework. Students interested in pursuing a certificate must first complete the following steps based on their current status:

Non-degree seeking VT students or individuals currently without a graduate status at VT

1. Complete the electronic Virginia Tech Graduate School "certificate seeking" application available at <https://applyto.graduateschool.vt.edu>. Applicants should apply before beginning the certificate program if they are already in a non-degree status at VT, but must apply no less than six months prior to completion of coursework. The application requires students to outline the classes they anticipate completing for the certificate (use the list of acceptable courses below). Students taking appropriate courses toward the certificate program prior to the application for certificate are not guaranteed admission to the certificate program. Applicants will be notified by letter if they are admitted into the certificate program.

2. If admitted, meet with a CEE academic advisor to confirm a final semester and coursework plan for completion of the certificate. See below for a list of contacts.

3. At the beginning of the semester for the final certificate course, students should submit the form called "Application for Degree or Certificate Conferral" through Hokie SPA. If students have taken different courses than outlined in the original application, they must complete the following form to receive approval for the changes: https://graduateschool.vt.edu/content/dam/graduateschool_vt_edu/GAAPforms/Application_Certificate.pdf

VT students already seeking a graduate degree

1. Students must complete the form called "Application for Certificate" and submit to the CEE department. The application form requires students to outline the classes they anticipate completing for the certificate. Applicants should apply before beginning the certificate program, but must apply no less than six months prior to completion of coursework. Students taking appropriate courses toward the certificate program prior to the application for certificate are not guaranteed admission to the certificate program. Applicants will be notified by letter if they are admitted into the certificate program.

2. If admitted, meet with a CEE academic advisor to confirm a final semester and coursework plan for completion of the certificate. See below for a list of contacts.

3. At the beginning of the semester for the final certificate course, students should submit the form called "Application for Degree or Certificate Conferral" through Hokie SPA. If students have taken different courses than

outlined in the original application, they must complete the following form to receive approval for the changes: https://graduateschool.vt.edu/content/dam/graduateschool_vt_edu/GAAPforms/Application_Certificate.pdf

Course Requirements

Students who wish to complete the Graduate Certificate Program in CEE must:

1. Complete 12 hours from the course requirements listed below. Note that grades for certificate courses must be a C or higher and overall certificate GPA must be 3.0 or higher. No 4000 level classes may be used as an elective course.
2. CEE students and non-degree-seeking students must complete the Application for Degree or Certificate Conferral form online in Hokie SPA by the deadline for the semester you will complete your certificate program. You will find the ADCC form under the Graduate Student Degree Menu/Application for Degree section of Hokie SPA.
3. If the outlined courses for your planned certificate have changed from the time you originally applied for the certificate program, submit a new version of the form called "Graduate Certificate Application" to the CEE Department by the third week of class in the semester you plan to finish your certificate. The link to this form can be found here: http://graduateschool.vt.edu/content/dam/graduateschool_vt_edu/Application_Certificate.pdf.

Limitations (All students, independent of major)

1. A graduate student may only receive one graduate certificate within the completion of the degree requirements for a graduate degree within the CEE Department.
2. No hours can be transferred from institutions other than Virginia Tech.
3. No credits below 5000 level may be used to satisfy the requirements.
4. Course substitutions for those not on the lists below without prior approval by the CEE Graduate Director are prohibited.
5. Degree-seeking students may only count 6 of the 12 credit hours from the certificate course requirements toward their degree.
6. Non-degree-seeking students in the certificate program who are later admitted to degree-seeking status may count all 12 credit hours toward both their certificate requirements and degree requirements.

Departmental Contacts

Blacksburg Campus contacts :

CEE Graduate Student Coordinator

Sarah H. Martin, shmartin@vt.edu , (540) 231-6069

Director of International & Graduate Education:

Lindy Cranwell, lindycra@vt.edu, (540) 231-7296

Specific Courses for Certificates in Urban Hydrology and Stormwater Management

Urban Hydrology and Stormwater Management

All students must complete CEE 5734: Urban Hydrology and Stormwater Management.

The remaining three courses must be selected from those listed below:

- CEE 5204:GIS Applications in Civil Engineering
- CEE 5304: Environmental Fluid Mechanics
- CEE 5324: Advanced Hydrology
- CEE 5714: Surface Water Quality Modeling
- CEE 5794: Environmental Engineering Principles
- CSES 5864: Advanced Wetland Soils and Mitigation
- An Approved Technical Elective Course



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Water Quality Management WQMC

Address:
Virginia Tech Civil & Environmental Engineering 750 Drillfield Dr. 200 Patton Hall,
MC: 0105
Blacksburg, VA 24061

Contact this Certificate

Email Contact(s):
• Blacksburg: Sarah H. Martin

Web Resource(s):
• Website

Phone Number(s):
• Blacksburg Campus:
540/231-6069

[Certificate Overview](#)

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Water Quality Management - Certificate Overview

The Charles E. Via, Jr. Department of Civil and Environmental Engineering (CEE) coordinates the administration of seven graduate certificates. In the field of Advanced Transportation Systems, three certificates are available: Air Transportation Systems, Traffic Control and Operations, Transportation Systems Engineering. Related to Environmental Engineering, three certificates are available: Treatment Process Engineering, Water Quality Management, and Urban Hydrology and Stormwater Management. The certificate in Civil Infrastructure Systems encompasses a variety of CEE disciplines with emphasis in Infrastructure Engineering.

How to Apply:
Fill out the online application for participation in the certificate program.



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Water Quality Management WQMC

Address:
Virginia Tech Civil & Environmental Engineering 750 Drillfield Dr. 200 Patton Hall,
MC: 0105
Blacksburg, VA 24061

Contact this Certificate

Email Contact(s):
• Blacksburg: Sarah H.
Martin

Web Resource(s):
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Phone Number(s):
• Blacksburg Campus:
540/231-6069

[Certificate Overview](#)[Admissions & Course Requirements](#)

Admission Requirements

The Graduate Certificate Program in CEE is open to on-campus (Blacksburg) students, full-time and part-time, who have been approved by the Virginia Tech Graduate School to take graduate coursework. Students interested in pursuing a certificate must first complete the following steps based on their current status:

Non-degree seeking VT students or individuals currently without a graduate status at VT

1. Complete the electronic Virginia Tech Graduate School "certificate seeking" application available at <https://applyto.graduateschool.vt.edu>. Applicants should apply before beginning the certificate program if they are already in a non-degree status at VT, but must apply no less than six months prior to completion of coursework. The application requires students to outline the classes they anticipate completing for the certificate (use the list of acceptable courses below). Students taking appropriate courses toward the certificate program prior to the application for certificate are not guaranteed admission to the certificate program. Applicants will be notified by letter if they are admitted into the certificate program.
2. If admitted, meet with a CEE academic advisor to confirm a final semester and coursework plan for completion of the certificate. See below for a list of contacts.
3. At the beginning of the semester for the final certificate course, students should submit the form called "Application for Degree or Certificate Conferral" through Hokie SPA. If students have taken different courses than outlined in the original application, they must complete the following form to receive approval for the changes: https://graduateschool.vt.edu/content/dam/graduateschool_vt_edu/GAAPforms/Application_Certificate.pdf

VT students already seeking a graduate degree

1. Students must complete the form called "Application for Certificate" and submit to the CEE department. The application form requires students to outline the classes they anticipate completing for the certificate. Applicants should apply before beginning the certificate program, but must apply no less than six months prior to completion of coursework. Students taking appropriate courses toward the certificate program prior to the application for certificate are not guaranteed admission to the certificate program. Applicants will be notified by letter if they are admitted into the certificate program.
2. If admitted, meet with a CEE academic advisor to confirm a final semester and coursework plan for completion of the certificate. See below for a list of contacts.
3. At the beginning of the semester for the final certificate course, students should submit the form called "Application for Degree or Certificate Conferral" through Hokie SPA. If students have taken different courses than

outlined in the original application, they must complete the following form to receive approval for the changes: https://graduateschool.vt.edu/content/dam/graduateschool_vt_edu/GAAPforms/Application_Certificate.pdf

Course Requirements

Students who wish to complete the Graduate Certificate Program in CEE must:

1. Complete 12 hours from the course requirements listed below. Note that grades for certificate courses must be a C or higher and overall certificate GPA must be 3.0 or higher. No 4000 level classes may be used as an elective course.
2. CEE students and non-degree-seeking students must complete the Application for Degree or Certificate Conferral form online in Hokie SPA by the deadline for the semester you will complete your certificate program. You will find the ADCC form under the Graduate Student Degree Menu/Application for Degree section of Hokie SPA.
3. If the outlined courses for your planned certificate have changed from the time you originally applied for the certificate program, submit a new version of the form called "Graduate Certificate Application" to the CEE Department by the third week of class in the semester you plan to finish your certificate. The link to this form can be found here: https://graduateschool.vt.edu/content/dam/graduateschool_vt_edu/GAAPforms/Application_Certificate.pdf

Limitations (All students, independent of major)

1. A graduate student may only receive one graduate certificate within the completion of the degree requirements for a graduate degree within the CEE Department.
2. No hours can be transferred from institutions other than Virginia Tech.
3. No credits below 5000 level may be used to satisfy the requirements.
4. Course substitutions for those not on the lists below without prior approval by the CEE Graduate Director are prohibited.
5. Degree-seeking students may only count 6 of the 12 credit hours from the certificate course requirements toward their degree.
6. Non-degree-seeking students in the certificate program who are later admitted to degree-seeking status may count all 12 credit hours toward both their certificate requirements and degree requirements.

Departmental Contacts

Blacksburg Campus contacts :

CEE Graduate Student Coordinator

Sarah H. Martin, shmartin@vt.edu , (540) 231-6069

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Director of International & Graduate Education:

Lindy Cranwell, lindycra@vt.edu, (540) 231-7296

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Specific Courses for Certificates in Water Quality Management

Water Quality Management

All students must complete CEE 5134: Engineering Aspects of Water Quality.

The remaining three courses must be selected from those listed below:

- CEE 5104: Environmental Chemistry
- CEE 5124: Fundamentals of Environmental Toxicology
- CEE 5194: Environmental Engineering Microbiology
- CEE 5714: Surface Water Quality Modeling
- CEE 5734: Urban Hydrology and Stormwater Management
- CEE 5794: Environmental Engineering Principles
- BSE 5404: Agricultural Non-point Source Pollution
- An Approved Technical Elective Course



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Watershed Management WSMC

Address:
Virginia Water Resources Research Center (0444) 210-B Cheatham Hall 310 West
Campus Drive
Blacksburg, VA 24061

Contact this Certificate

Email Contact(s):

• Kevin McGuire

Web Resource(s):

• Website

Phone Number(s):

• Kevin McGuire:

540/231-6017

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Certificate Overview

In the 21st century, challenges that relate to watershed management and the need to protect water quantity and water quality will be intensified in Virginia and the nation, owing to increased water demand, changes in land-use, and other competing interests. Management of water resources is a critical issue facing governmental agencies, as well as the private/industrial sector and citizens. Universities and colleges have a major responsibility to prepare future water and land managers to meet these challenges. Future water managers and decision makers need knowledge and training in natural science, technical assessment, economics, planning, and policy. In recent years, it has been recognized that the most effective approach to management of water resources is at the watershed scale with input from various stakeholders. Furthermore, there have been significant advances in understanding watershed science both in the natural and social sciences, and there is a national trend to integrate various facets of watershed studies in interdisciplinary programs. The Watershed Management Certificate (WSMC) program at the graduate level integrates existing programs and courses from five colleges and ten departments at Virginia Tech to provide an interdisciplinary and substantive understanding of watershed science, policy, and decision-making. The program provides excellent opportunities for students from many disciplines to study watershed management and develop interdisciplinary skills necessary for effective professional work in this emerging field. The program is designed to prepare Virginia Tech graduates for critical future tasks and will be a strong incentive for others who consider enrollment at Virginia Tech, Blacksburg.

How to Apply:

Fill out the [online application](#) for participation in the certificate program.



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Watershed Management WSMC

Address:
Virginia Water Resources Research Center (0444) 210-B Cheatham Hall 310 West
Campus Drive
Blacksburg, VA 24061

Contact this Certificate

Email Contact(s):

- Kevin McGuire

Web Resource(s):

- Website

Phone Number(s):

- *Kevin McGuire:*

540/231-6017

[Certificate Overview](#)[Admissions & Course Requirements](#)

Admission Requirements

Virginia Tech students accepted in any graduate program category: PhD, MS, MA, Commonwealth Campus, or Non-Degree can be admitted into the WSMC program by completing the Graduate Certificate Application, and completing a plan for taking courses required on the course checklist below. Students should meet with an academic adviser familiar with the classes on the list below and submit the application form to Dr. Kevin McGuire for the Certificate Program Approval signature no less than six months prior to completion of coursework.

After completing the 11-12 hours of courses required, take the course requirements checksheet (available on the WSMC webpage: <http://www.vwrrc.vt.edu/watershed-management-graduate-certificate>) to Dr. McGuire for signature. Students should bring a copy of their transcript for verification purposes. Submit the signed course requirements checksheet to Dr. McGuire no less than six months prior to completion of course requirements, or as soon as possible to meet the Graduate School deadlines. Transfer credits are not permitted.

Upon successful completion of certificate requirements, an Application For Certificate Conferral must be signed by the department and submitted by the Application for Degree deadline in the term in which the certificate will be awarded. The Graduate School will then check to see that courses listed on the Certificate Application form were satisfactorily taken (i.e., grades for certificate courses must be "C" or higher and the overall certificate GPA must be 3.0 or higher).

Course Requirements

A. Required Core Course: Watershed Management (3 credit hours):

Choose one of the courses below:

UAP 5134G Land Use and Environment: Planning and Policy

UAP/NR 5414 Natural Resources Planning (NCR)

B. Additional Courses (8-9 credit hours):

1. Watershed Science (choose 1 course, 3 hours):

BSE 5404 Agricultural Nonpoint Source Pollution

FREC 5354G Advanced Forest Soils and Hydrology

LAR 5304G Topics: Advanced Landscape Architecture Technology - Hydrology

FIW 5534G Advanced Wetland Ecology and Management

NR 5884 Watershed Science, Education & Leadership (NCR)

CEE 5324 Advanced Hydrology (NCR)

CEE 5734 Urban Hydrology and Stormwater Management

GEOS 5804G Advanced Groundwater Hydrology

FIW 5814 Stream Habitat Management

2. Watershed Analysis (choose 2 courses, 5-6 hours):

BIOL 5034 Ecosystem Dynamics

BSE 5244 GIS in Hydrologic Analysis

BSE 5354 Nonpoint Source Pollution Modeling

CEE 5204 GIS Applications in Civil and Environmental Engineering (NCR)

FREC 5254 Remote Sensing of Natural Resources

FREC 5264 GIS Applications in Natural Resources Management

LAR 5044 Land Analysis and Site Planning

CSES 5854 Advanced Wetland Soils



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Women's & Gender Studies WGSC

Address:
507 McBryde Hall (0137) Virginia Tech
Blacksburg, VA 24061-0137

Contact this Certificate

Email Contact(s):

- Director

Web Resource(s):

- Website

Phone Number(s):

- *Main Office:*
540/231-6878

- *Director's number:*
540/231-5923

[Certificate Overview](#)[Admissions & Course Requirements](#)

Certificate Overview

The Graduate Certificate in Women's and Gender Studies extends graduate students' work in other disciplines by exploring feminist theoretical perspectives and analyzing the structural and interpersonal dimensions of race, ethnicity, class, gender, and sexuality. Students complete nine hours of coursework together with a thesis or dissertation addressing an issue of gender or sexuality in a significant way.

How to Apply:

Fill out the online application for participation in the certificate program.



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Women's & Gender Studies WGSC

Address:
507 McBryde Hall (0137) Virginia Tech
Blacksburg, VA 24061-0137

Contact this Certificate

Email Contact(s):

• Director

Web Resource(s):

• Website

Phone Number(s):

• *Main Office:*

540/231-6878

• *Director's number:*

540/231-5923

[Certificate Overview](#)

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Admission Requirements

Graduate standing in primary discipline and director approval.

Course Requirements

The WGS Graduate Certificate requires 9 hours of coursework, including WGS 5914 Feminist Theory and WGS 5924 Feminist Research Methodologies. Other courses must be either WGS courses or WGS-approved from other disciplines. Thesis or dissertation must address gender or sexuality and have at least one WGS faculty member or affiliate faculty member from other departments on the committee.

Additional Information

Please contact the WGS Director at spjohnson@vt.edu to discuss the Program, course options, and graduate student activities. Friend us on FaceBook at <https://www.facebook.com/wgsatvt>