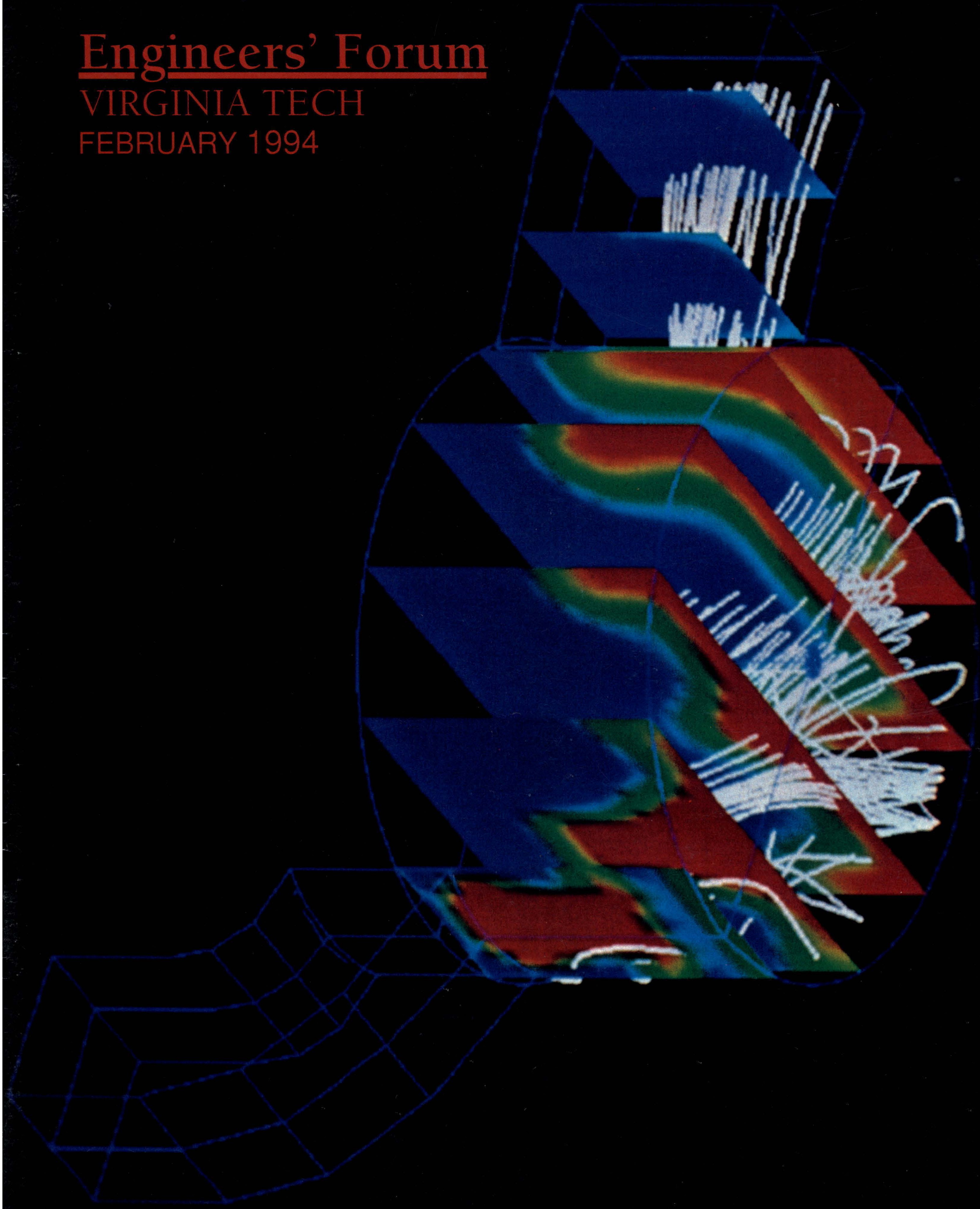
Engineers' Forum

VIRGINIA TECH

FEBRUARY 1994



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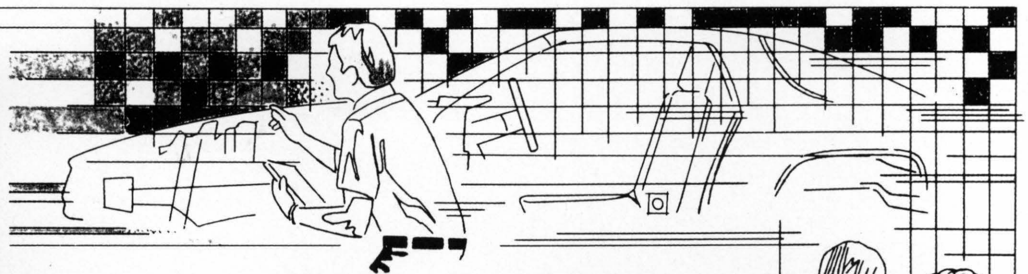

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Opportunities inside

Opportunity! College graduates blame a lack of it on the lethargic economy, but in this recession one industry continues to grow and show promise for the future. The telecommunications industry is ready to explode into the next millennium, and will provide opportunity for today's engineering graduates.

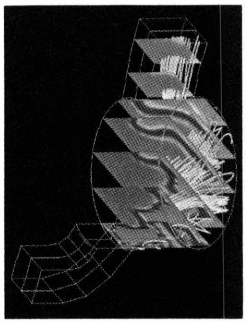
The projected growth of the telecommunications industry over the next decade is from 700 billion dollars to 3 trillion dollars. This has provided incentive for companies to expand into this field, and has resulted in companies expanding their engineering workforce.

Companies have projected where the industry will go in the future, and have used these projections to advertise their services to customers. An example is the AT&T ad which depicts video phones as a common household item. Technology such as this exists but in primitive form.

Words like information superhighway and spectrum auction give images of high tech transportation and Wild West cowboy sales, but what is being transported and sold is data.

Engineers will be needed to improve designs of equipment such as video phones, digital processors, and personal communication systems. This is necessary in order to transport data in larger quantities more quickly and reliably. Although inventing and improving this equipment is the obvious connection with engineering, opportunities also lie elsewhere.

The telecommunications industry is constantly in the media. "The White House is backing the information superhighway." "The Federal Communications Commission (FCC) announced the rules of a spectrum auction which could raise 10 billions dollars for the U.S. Treasury." Words like information superhighway and spectrum auction give images of high tech transportation and Wild West cowboy sales, but what is being transported and sold is data. Engineers are needed to take the mystery out of these words so that the general public understands what services are being offered. This leads to opportunities in sales, technical writing, and advertisement, not traditional careers for engineers. It is exciting to realize how versatile today's engineering graduate has become.



ON THE COVER

Computational fluid dynamics, a common supercomputer application, helps engine designers see what's happening inside. The turbokiva application from Cray Research, Inc., is on the leading edge of engine simulations and generated the cover picture. Special thanks go out to Mardi Larson and Conrad Anderson of Cray Research for making this exciting cover possible.

EDITORIAL

The government has realized that telecommunications is a strategic industry important to keeping this country competitive; therefore, the past year has seen monumental legislation passed to help make this industry more competitive and more profitable. The spectrum auction mentioned earlier is a prime example of how many groups can profit directly from the telecommunications industry. Wireless communications companies offer their services at FCC licensed frequencies. Industries, such as the cellular phone market, are becoming more lucrative and more companies want to be licensed. The FCC's spectrum auction will sell licenses at new frequencies to permit these companies to operate. This will raise money for the government, make the industry more competitive, and create opportunities for new graduates. Once again, one should not overlook opportunities outside of industry.

Only two percent of the members in Congress have an engineering background. Yet these are the individuals who are making toady's legislative decisions for tomorrow's technology. With their technical background, engineers are the most equipped individuals to deal with these issues. One could say that engineers have a responsibility to go into politics to make up for the lack of technical representation.

Opportunity! Our generation has been accused of complaining too much about the lack of it. The telecommunications industry will provide opportunity for today's engineering graduates. Opportunities not limited to traditional positions in design or implementation, but in new areas such as politics, sales, and technical writing. Today's engineering graduates have plenty of opportunities available. This generation does not have to be remembered as complainers, but as the generation that brought the world through the communication revolution.

Mike Reese, Editor-in-Chief

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This Little Piggie...

The future of genetic engineering is here at Virginia Tech

by Betsy Shadis

Dr. William Velander (l) and Dr. William Droham display a transgenic pig.

Once thought to be a part of the distant future, genetically engineered animals are quickly becoming a reality. In particular, great advances have occurred in the genetic engineering of livestock for purposes of making therapeutic proteins. Previously, these proteins could only be obtained in limited quantities from human plasma. Some of the leading research in genetic engineering of livestock is being done on Virginia Tech's campus.

About seven years ago Dr. William Velander, a biochemical engineering professor here at Virginia Tech, and Dr. William Drohan, a molecular biologist at the American Red Cross (ARC), began a joint research program to recover protein C from human plasma. Protein C is an important anticoagulant found in trace quantities in human plasma. Anticoagulants are used in the body to control the clotting of blood; overclotting frequently creates serious complications such as heart attacks, septic shock, and vascular damage.

Researchers began by developing purification methods for proteins extracted from human plasma. The researchers soon found there was not enough protein C in human plasma and turned to transgenic livestock as a potential source. A cross-disciplinary team of biochemical engineers, molecular biologists, dairy and animal scientists was assembled. Dr. Tracy Wilkins, Virginia Tech's Biotechnology Center Director, assisted in the early organization of campus researchers interested in transgenic animal research. Eventually, the laboratories of Professors John Johnson of Anerobic Microbiology, Frank Gwazdauskas and Mike Akers of Dairy Science, James Knight of Animal Science and Bill Velander of Chemical Engineering undertook the transgenic animal research project with the ARC.

A transgenic animal is an animal which has incorporated foreign genetic information into its own genetic makeup. In the context of transgenic animal research, a synthetic foreign gene is first assembled or cloned from selected elements of copies of genes made by a "biochemical xerox machine." That is, a bacterial cell is used to make many copies of selected elements of foreign genes first obtained from tissue samples of the animal of interest.

In the case of human protein C, Dr. Drohan's research group at the American Red Cross used essential information encoding the human protein C structure copied from the genetic message isolated from human liver. Likewise, genetic switches were copied from messages and also directly from the genes which control biosynthesis or expression of milk proteins in mice. These "milk gene switches" are well conserved in mammals and therefore mice provide a convenient source for use in other animals such as pigs, sheep, goats and cows. The copies of the mouse milk and protein C genes were then combined to produce a chimeric gene capable of directing synthesis of protein C in the milk of mammals (When fragments from any organism recombine into a different genome the new gene is called a recombinate gene.).

While there are several ways foreign genes can be introduced into the tissues of animals (such as by using altered viruses as carriers), Virginia Tech researchers use a method called microinjection to make protein C transgenic pigs. Professor John Johnson's laboratory prepared the ARC protein gene for microinjection into mouse and pig embryos; an aqueous solution of about 1000 copies of the protein C gene per picoliter was made. The laboratories of Professors James Knight and Frank Gwazdauskas recovered one-celled embryos from donor pigs and then microinjected about 2000 copies of the protein C gene into each of the embryos.

A transgenic animal is an animal which has incorporated foreign genetic information into its own genetic makeup.

The gene was trialed in mice as well as in pigs. Protein C recovered and characterized from the milk of these animals by Dr. Velander's laboratory was found to be made by the mammary gland of pigs at about a 1000 times greater rate than reported in the best cell culture bioreactor. The activity of the protein C was also great enough to have promise for use as a anticoagulant.

Pigs were chosen because they have a short generation time, large numbers of progeny per litter and they are capable of two litters per year. They can also produce about four liters of harvestable milk per day for about 160 days per year. Tech has about twenty lactating female pigs for research study and has had as many as 40. About 1 tenth of one gram of protein C is yielded from one liter of pig milk.

Over the last four years the transgenic animal research group at Virginia Tech have graduated four Ph.D.'s in biochemical engineering, three Ph.D.'s in dairy science, one M.S. in animal science, as well as about 10 undergraduate student researchers who have participated in the project. The projects have included studies in purification of proteins from milk, gene delivery, gene regulation, and developmental biology of transgenic embryos. About $1.7 million in grants from ARC, the National Science Foundation, and Alexion Pharmaceuticals has been received over the past five years to do transgenic animal research at Virginia Tech.

A significant portion of Virginia Tech's effort is now directed at the study of genetic regulation using other or modified mouse milk gene switches. In addition, genes for other important therapeutic proteins are being trialed in mice, pigs, and cows.

While the animals produced at Virginia Tech will probably not be founders of the actual herd, valuable data is being collected about the genetic stability of the offspring from animals maintained at the VT Swine Center. The genetic analysis and protein characterization is now done jointly by the American Red Cross and Virginia Tech.

It will be at least another two to three years until the human trials begin with protein C developed here at Virginia Tech. But in the meantime, this project has already received much attention from The New York Times, The Wall Street Journal, CNN, What's Happening in Chemistry, Science Journal, and many other publications. Dr. Velander stated that, "Tech is now recognized as a leading edge research institution in the biosynthesis and downstream processing of genetically engineered proteins for therapeutic applications."

It is hoped that the research with protein C producing livestock developed here will lead to the availability of other recombinant protein therapies to treat human diseases. EF

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VIRGINIA POWER

Love at first sight?

Fundamental engineering instruction offers a glimpse into the realm of possibility

by Kevin W. Leclaire

FORTRAN. Engineering Ethics. Technical Drawing. Cadkey. TK Solver... Some of you have suppressed your memories of these experiences, while others may remember different aspects of Engineering Fundamentals. Can you imagine drafting with a T-square and triangle instead of Cadkey? It wasn't so long ago that there weren't any alternatives.

This year, in order to keep Tech engineers in tune with state-of-the-art technology, freshmen engineers were required to buy a high-end multimedia-equipped PC. The new minimum computer requirement now includes a CD-ROM drive and other features which couldn't even run on a system bought as recently as 1991. Technologically, the computer systems for the class of 1997 engineers and beyond are far superior to those of the previous years — but how has the instruction for engineering freshmen progressed during the same interval and why do each year's students still shudder at the mention of FORTRAN?

For most engineering students at Tech, Engineering Fundamentals (EF), is the first exposure to what they should expect in both their major and their career. In high school, they were exposed to elements of engineering: physics, math, chemistry, etc. They have always been exposed to the products of engineering: the automobile, air conditioning, packaged foods, aspirin, etc. For whatever reasons, they chose engineering; their first impression with becoming an engineer occurred in EF.

Therefore, shouldn't it be the first priority of the engineering fundamentals curriculum to give these students a good first impression? It can be assumed that the better a student's first impression concerning their intended career, the more positive their attitude towards learning the material. Such logic, however, assumes the instructor's objective is to encourage their charges in engineering. If, on the other hand, an instructor felt it was his duty to discourage those students who might not have the skills or motivation to be an engineer, then he would likely give students a poor first impression of engineering. All the negative consequences would follow. Fortunately, Tech has very few EF professors who conform to this "Weeder Principle."

Designing a course which will be useful to future majors in all of the disciplines offered at Tech can be difficult at best. As such, EF has been under continual revision as Dr. Daniel Ludwig, head of the EF department, and others work to make EF evolve with the changing times. The Dean's Committee of the Student Engineer's Council (SEC) wrestled with the relevancy of the content of the EF course and made several observations and came to several conclusions about EF.

In order to appropriately analyze the EF curriculum, one must first understand the purpose behind the curriculum. If the purpose is only to teach the "high standards of professionalism..." and proper format and organization, then EF is little more than a class in discipline. However, if its role is to help develop the ability of the young engineer, then reexamination of the way this goal is met is in order. The need to maintain a focus on what is really important cannot be overemphasized. Many students were grateful to get out of EF and find that their majors were nothing like EF.

Creativity is one of the fundamentals of engineering often not given the credit it is due. As an engineer, one will be faced with a large variety of problems, not all of which fit into previous experience. To be a successful engineer you will have to demonstrate creative problem solving to examine all possible solutions. It is one of an engineer's most important resources which deserves to be developed. However, the stated objectives of fall semester EF, which mentions the need to solve problems "following proper procedures and format," fails to mention creativity once.

Only a few schools have as comprehensive a program for freshmen as Tech does with its EF curriculum. Most curricula involve separate programming classes and a few have a special Freshman Seminar. An example of another approach is the freshman seminar offered at Wright State University in Ohio. It is taught solely by upper class students and involves several presentations by faculty who discuss the various aspects of Engineering at their school. The course leaves room for a significant amount of in-class advising and it seems to really help to make Wright State engineers feel like they belong. The

ENGINEERING FUNDAMENTALS

course, with only limited enrollment at present, has a long waiting list each semester it is offered. Engineering Fundamentals at Tech is fairly unique in its depth of Freshman education, even though some of its goals may be different from that of other programs.

Even with the relative depth of EF at Tech, are the most useful topics being covered? A case could be made that some very important basic skills are ignored at present, while others like lettering and technical drawing are overemphasized.

One of the overlooked skills any engineer should have upon graduation is familiarity with spreadsheets. However, due to "prohibitive costs," spreadsheets were removed from the software requirements in the computer package.

Many students now perform all sorts of calculations by longhand in more advanced classes when they could be saving hours with a simple spreadsheet.

One reason for not continuing instruction in basic spreadsheet skills was that professors in these courses didn't express a need for the students to have these skills. Why would they when all they see is the finished product? The Dean's committee has unanimously favored the introduction of at least basic spreadsheet instruction.

Jennifer Roeder, a senior in Materials Engineering, said it should "absolutely be included" as part of EF instruction. Shouldn't we, as engineers, be using the tools to accomplish our work as efficiently as possible? Wasn't that always part of the justification behind the computer package?

At the root of much discussion concerning EF instruction lies the programming language issue. A popular view among engineering students concerning the current language is expressed in the cartoon Freshman Fifteen, which states simply, "FORTRAN is evil." This issue has been debated perhaps more than any other, so let me list the pros and cons of three popular programming languages, and you can form your opinion on the matter. First of all, there is PASCAL, which is perhaps the easiest structured programming language to learn. It is relatively user friendly and very easy to read, but is not widely used.

Next we have the traditional engineering language of choice, FORTRAN. A lot of the old code still in use today was written in FORTRAN, therefore it's useful to be able to understand this language. However, FORTRAN is not as logical as Pascal, nor as powerful as either Pascal or C in many ways.

Many students were grateful to get out of EF and find that their majors were nothing like EF.

C is the most powerful language, but that also means its also the most dangerous for the novice programmer as it opens up the whole system memory for manipulation, which can be a quick way to get your system to crash. C is much easier to learn if you already know another language, particularly Pascal, but could lead to as much or more frustration as FORTRAN without any prior experience programming.

When considering whether to choose FORTRAN or C, the college faces the same dilemma as many businesses in the professional world. They already have a stake in FORTRAN, be it in subroutine libraries and in teaching familiarity. Yet because C is so much more powerful it is becoming very popular and may eventually replace FORTRAN (although not in the near future, especially since the new FORTRAN standard will make it perform more like C).

The Electrical Engineering Department wants their students to learn C and took over the engineering elective in C (which was unfortunately then restricted to EE majors only). Every other department seems to have no preference although some specific classes require the use of FORTRAN.

Scott McKeel, a graduate student in Aerospace and Oceans Engineering, voiced the view of many students by saying, "I wish there was a way to learn C better." Scott, a diehard FORTRAN user was surprised when, at work, his employer asked him to learn C.

Any number of alternatives of varying levels of difficulty in implementation exist. One would be to separate the programming from EF and students would be required to take, for example a one credit EF course first semester, and a one or two credit course in their choice of programming language. This would allow the students to select the language they feel they are ready for, enabling more experienced programmers to choose C.

If it was a concern, entrance in the C course could be restricted to those who had prior experience with another language. In the near future, however, the only expected change be the reopening of the current C elective to non-Electrical Engineering majors.

Another issue of concern for Freshmen while they are still classified as general engineering majors is the quality of advising. This is of special importance in the next month as they prepare to select their specific major. Fortunately Tech engineers aren't in the same boat as University of Virginia engineers. They have to select their engineering discipline before they ever arrive on campus.

It is acknowledged that EF professors who act as their students academic advisors for the first year will not be able to answer all of a student's questions concerning specific disciplines. Therefore, the EF department shows videos during class which present every major to the students. For a change, the freshmen should expect some new

Continued on next page

ENGINEERING FUNDAMENTALS

Continued from previous page

videos which the Dean's office and the various departments have been putting together to replace some of the older videos which our parents could have seen if there had been VCRs when they went to school. Students are encouraged to attend the Engineers Week activities during the week of Feb. 20-26, 1994, and if they have further concerns with requirements or expectations for a certain major, they can consult their undergraduate catalog. Another alternative would be to talk to a student already in the major or to set up an appointment with the academic counselor of the department in question who should be happy to talk to interested students.

As mentioned earlier, other schools incorporate different variations of advising into their curriculum. At Tech, some students feel our first advisors may be biased by what they observe in their class as it is their primary source of information about their students. Although the in class observation is one of the justifications for this advising system, it can also be one of its biggest limitations. One example involved a student who didn't do very well in a certain professor's EF class, although he maintained good grades in his other classes. He was advised that he "didn't have what it took" to be an engineer. The individual is now near the top of his chemical engineering class, a major for which he felt most of the instruction in EF was not useful. Hopefully, in the future the few students who have problems with their advisor will not be discouraged and will seek assistance elsewhere.

In most cases where students find something they would like to change, they still have a stake in the outcome. When students enter engineering at Tech, they are still getting their first impression, and are too unfamiliar with the system to do anything about problems or things they would like to see changed. By the time they have had more courses and begun to understand how much they learned in EF was useful and how much they will never use again, it is too late for them use their experience with the course to get what they would have like to have received. Therefore it falls upon the faculty and administration to reexamine the whole freshman engineering experience and adapt it to the present needs of the students. The Dean's Committee has offered their input as a student group which acts as a liaison between the student body and the administration. The ball now rests in the administration's court. EF

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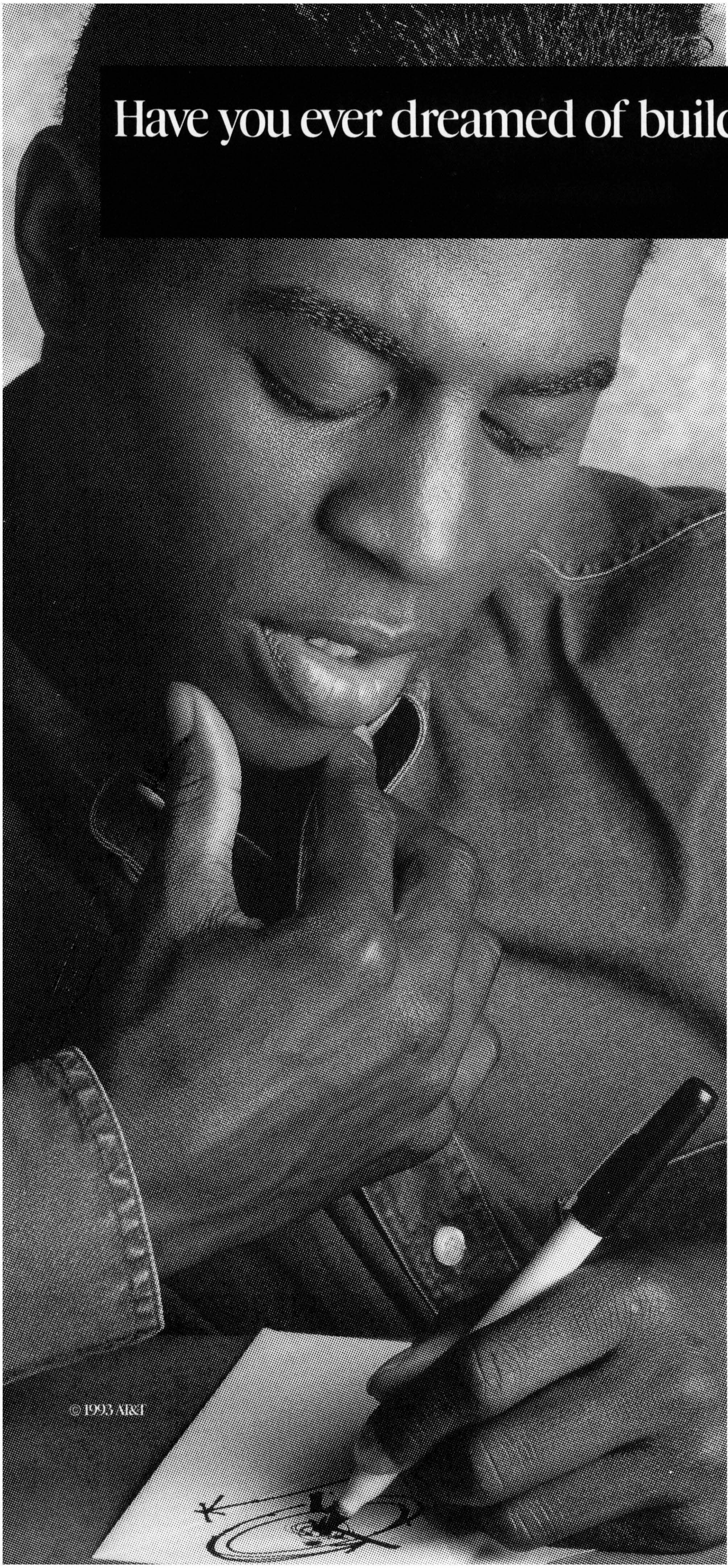

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Mining engineers discover rich opportunities underground

by Jessica Wilt

It is one of the oldest and best departments of its kind in the country. It houses two internationally-known research facilities which are the only two of their kind in the United States. It provides international career opportunities for undergraduates and graduates alike. The first graduate of Virginia Tech was a graduate of this department.

No, it's not the College of Agriculture, and it's not the Mechanical or Electrical Engineering departments. It is Tech's Mining and Minerals Engineering department.

Most students know very little about the Mining and Minerals Engineering department. There is an excellent faculty-to-student ratio that allows extensive academic interaction outside of the classroom. There are many specific areas of study covered in the curriculum, including exploration, evaluation, development, extraction, mineral processing, conservation and the environment, and mineral economics. Because the department is relatively small, every mining engineering student receives some sort of scholarship, averaging $2500 per year per student. This is a result of the extensive support from industry and distinguished alumni.

Dr. Michael Karmis, head of the department since 1987, thinks this support demonstrates the great need for good mining engineers.

Worried about the job market? Mining engineers aren't. In past years there have been more jobs than graduates available — and some of the highest salaries for graduating engineers are offered in this field.

Also, undergraduate mining engineers have excellent internship and co-op opportunities to provide early experience. The department has a strong commitment to providing valuable summer experience, often matching students with companies close to home or in other countries such as Australia, South Africa, and Canada.

Recently, students applied for work with Summer Job '94, a program run by an association of regional companies in the stone industry. Based in Washington D.C., the association will provide students with a job in one of the many quarries in Virginia.

So, what is it like to be a mining and minerals engineer? It's 5:00 a.m. The beam of light from your hard hat pierces the darkness that surrounds you. You are in a space less than a meter tall and at least four kilometers beneath the surface of the earth. You are wiring a face that later will be blasted and could bring the dirt ceiling tumbling down on top of you.

Yet you aren't nervous or claustrophobic; you are amazingly calm and comforted. You know exactly what your job is and how to accomplish your tasks. You are confident that your knowledge and experience will assist you in every situation that may arise. (If they don't, you'd better get out fast!) You are a mining engineer and this is your daily routine.

It's 5:00 a.m. The beam of light from your hard hat pierces the darkness that surrounds you. You are in a space less than a meter tall and at least four kilometers beneath the surface of the earth.

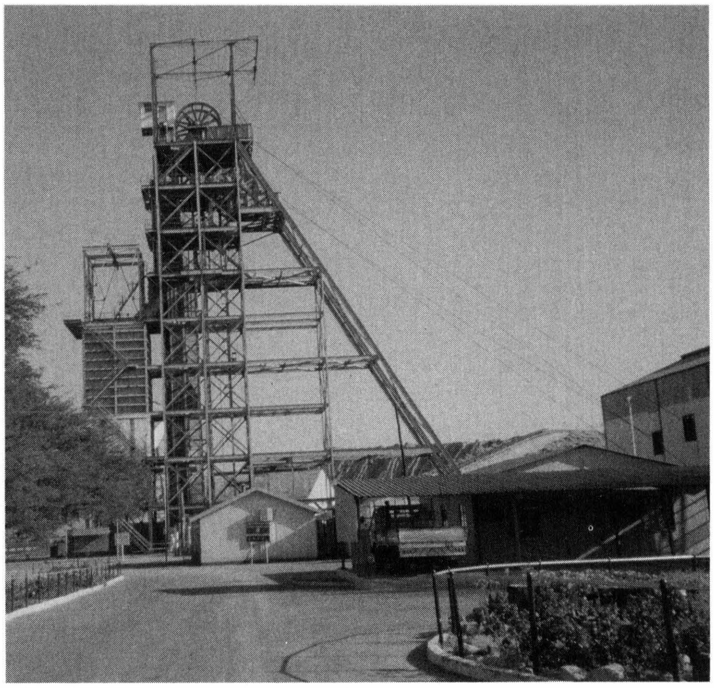
One of the most exciting available opportunities is a summer internship program with Johannesburg Consolidated Investments (JCI). JCI owns one of the largest mining operations in the world and is a leader in wide-reef, deep-level ore bodies.

Begun in 1889, JCI is the oldest of the South African mining finance houses and is at the heart of the South African business economy. JCI own the largest platinum reserves in the world. It has huge gold and uranium mines and many other reserves of coal, nickel, chrome, vanadium, manganese, and more.

Aside from its mining and minerals processing operations, JCI is a financial institution involved in the motor vehicle industry, real estate, breweries, as well as newspapers and other publications.

JCI interviews at universities around the world to bring in a wide variety of students. For many years, three to five Tech students were recruited to be learner-

MINING & MATERIALS ENGINEERING



The entrance to one of the JCI mines. The tower is a conveyer system into the mine.

miners. They spent their summer in Johannesburg, South Africa gaining "wonderful experience" according to Dr. Karmis.

The students involved agree. Sean Stewart considers the work he did in JCI mines in 1992 better experience than he could have received here in the United States.

The hard rock mines provide deeper mining, extending some 21 kilometers. Ed Woodson, who also worked in 1992, agreed that the extra-rich deposits provided an excellent work experience.

The training encompasses all aspects of the engineering process, from surveying to mining and minerals processing and gives students an opportunity to work with students from Sweden, Finland, and Great Britain.

Most students admit there is some danger involved with mining engineering, but safety is important in mines. Although at JCI there are strict guidelines, few safety inspectors were employed. The students commented that inspectors technically held a government position, but were paid by the mining companies. The inspectors were not educated in most of the engineering aspects and sometimes mistakes happened, although infrequently. Miners and mining engineers try to keep the mines as safe as possible.

The students came away with more than just valuable mining experience. They had a first-hand look at the political troubles brought on by the policy of apartheid. For the most part, the laborers were black and the miners and engineers were white. Woodson says he met a lot of good people, but as a whole, the situation was stereotypical. In general, the Afrikaners were very racist. He recalled an incident where he was warned not to share his food with the black laborers. Woodson continued acting as he always had, but hid certain actions from disapproving eyes.

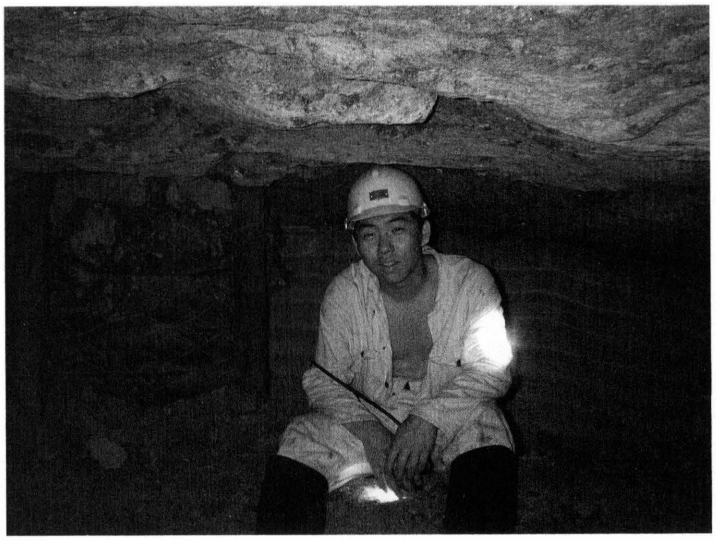
The United States' dealings with South African political policies have always been directly related to mining resources. Western nations rely heavily on South Africa for chrome, manganese, vanadium, and platinum. These minerals are used in the refining and production of specialty steels used in many industries such as aerospace and machine tools.

The question of sanctioning and whether to try to force change has always been controversial. With recent changes in the political environment, policies seem to be moving in the right direction, but the situation is still unstable.

The instability is the reason no mining engineers from Tech went to work for JCI this past summer.

Dr. Karmis hopes students will again work in South Africa. In the meantime, the department continues to provide an excellent learning environment, both in the classroom and through employment opportunities. The curriculum covers both traditional and innovative technologies.

If you are at all interested in the department, stop by Holden Hall. You might discover that there is a lot more to the Mining and Minerals Engineering department than you could ever imagine. EF



Photos courtesy of Bo Kim

Mining Engineering student Bo Kim pauses for a breather while deep in one of the JCI mines in South Africa.

TEACHER FEATURE

The mechanics of being a great professor

by Jessica Wilt

A little over ten years ago Charles Reinholtz was on an airplane leaving Florida for an interview at Virginia Tech. The young doctor of mechanical engineering, who attended the University of Florida for the entire span of his undergraduate, masters and doctoral studies, was uncertain about his future as a professor in Blacksburg, Virginia.

A connection at the University of Florida had recommended the position at Tech, but Reinholtz did not know much about the area. Ironically, on the plane sitting next to him and his wife was a mechanical engineering graduate of Virginia Tech.

Seeing the literature Reinholtz was carrying with him for the interview, the Tech alumnus began a conversation. During that plane ride Reinholtz heard Virginia Tech and Blacksburg extolled as an extraordinary educational environment. The alumnus expressed his wish to still be able to live in Blacksburg.

This preview had a calming effect on Reinholtz as he arrived at Tech. During the interview, it became evident that what he wanted and what Virginia Tech wanted matched perfectly.

What was evident at that interview is still very much evident today. Fascinated by the workings of high-technology mechanisms, Reinholtz works extensively in robotics. He has taught robotics for the past five years, and is considered by many students to be the robotics "guru" here at Tech. Outside of the classroom, he has worked on many projects with private industry: Nautilus, Milliken, BioConversions and Babcock & Wilcox Nuclear Service Company (BWNS).

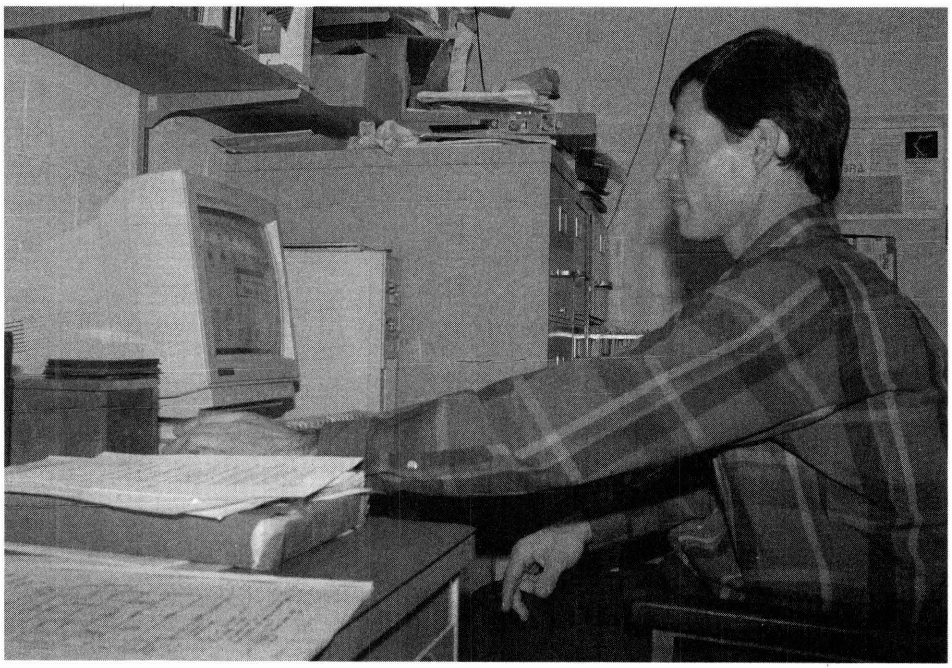


Photo by Rich Parish

Dr. Charles Reinholtz, hard at work.

It is with BWNS that Reinholtz has done work on the COBRA project. COBRA is a manway-mounted, electric motor driven manipulator for the inspection and repair of steam generators. Basically, it is a robotic arm for use in nuclear reactor steam generators. Reinholtz initiated contact between BWNS and Virginia Tech in 1988. Initially, BWNS did not have work for Tech, but later, when they wanted to create a robotic manipulator, they turned to Tech for ideas. Ever since, Reinholtz and various students have been involved with COBRA, from the initial design stage to the testing of prototypes. Other recent projects with BWNS have included URSULA, an underwater manipulator.

Reinholtz feels that it says something about the university and the mechanical engineering department that private industry trusts the work done here and therefore keeps returning with more research work. Others feel that it also says something about Reinholtz.

Virginia Tech recently honored Reinholtz with the Wine Award for university teaching excellence. Nomination for the Wine Award is initiated by students and then finalized by a faculty committee. When asked about the award Reinholtz says that he feels honored to receive it, especially because students initiated it, but that he is only an average teacher and his talents lie elsewhere.

For Reinholtz, being a good professor means more than being a good lecturer or a good researcher. Involvement with students makes the difference in the teaching experience. He says that he enjoys working with students, helping them to succeed, and advising them on their careers and futures. This desire to give his time to students is the quality most noted about Reinholtz. He gives students his home telephone number and can sometimes be found working on project models in his basement with them. He serves as the faculty advisor for the Virginia Tech branch of the American Society of Mechanical Engineers. Students can also always count on him for help in finding valuable work experience and research projects.

When asked about his future plans, Reinholtz says that he honestly has no major plans. He just wants to stay on the front line in his work and never let himself get too involved in the extras that go along with being a professor, such as committees and panels. For Reinholtz, success comes with the success of his students. EF

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FEATURE

SUPERCOMPUTERS:

The new generation of research tools

by Aaron Golub

They are machines designed to perform at the upper regimes of current abilities, like the Ferrari which is able to exceed 200 miles per hour. They are a very real part of modern life. Extremes are part of everything, and in our society thirsty for the surreal, these extremes can become icons, capturing the imagination of countless followers.

From 200 mph supercars to nimble jet fighter planes, these peculiarities normally find their way into our lives only through movies, wall posters, or day dreams. However, there is such an extreme soon to become a very real part of the Virginia Tech academic community.

Several departments have earmarked funds to purchase what is called a supercomputer. "Supercomputer" is not a new term, but is a vague one to most people. Several definitions of the term exist, but it would suffice to define it as, "among the most powerful computers being produced at the time." Just how powerful a computer belongs to today's group of supercomputers? A computer about 150 to 200 times as fast as the fastest Pentium PC available, with perhaps as much as 1000 megabytes of RAM and costs in excess of two million dollars. With such a high price tag one may ask, "Why do we need a computer that fast?"

There are as many answers to this question as there are problems in science, economics, mathematics, and engineering. For nearly a hundred years, the computer has been seen as a problem solver, a simulator, a predictor. There have always been problems too complex for current technologies, from the abacus to the slide rule to the digital computer. This is where the supercomputer derives its importance and meaning: to solve problems only dreamed of, to answer centuries old questions, to model phenomena without having to drop out half of the equations for simplification, to expand the outer boundaries of problem solving ability.

A look at some common problems addressed using supercomputers can give some insight into why the outrageous speed and memory are essential. For example, flame simulation for combustion modeling might involve 300 spatial grid points, each involving 20 chemical species with 5 or 6 properties for each species (density, extinction rate, etc. The governing equations for the flame require solving an equation with about 15 terms. This requires 20,000 numerical operations (probably a low estimate) at each grid point and time step. Using a time step of one tenth of a millisecond means that for a five second simulation, 300 billion calculations will be performed. For a very fast Pentium PC, crunching numbers at 3 million operations per second, this would take 27.8 hours. For today's supercomputer, crunching numbers at about 2.0 billion operations per second, these same calculations take two and a half minutes. This is for a very small job. Some jobs take weeks on supercomputers, which translates into years on the fastest PC.

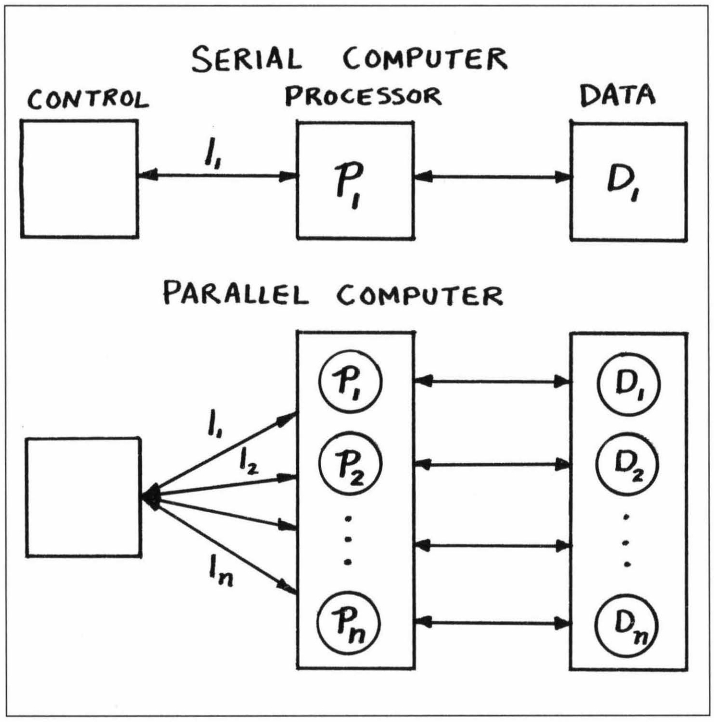
Weather forecasting is another problem aided by supercomputers. Equations for wind speed, temperature, density, pressure, and humidity are coupled with complex equations for radiation, storms, and evaporation for millions of spatial grid points. Here a simulation for one small geographic region might take two to three hours.

Another common problem addressed by supercomputers is geotechnic modeling. Here, millions of seismic data pieces are processed to model subsurface terrain. This aids oil reservoir modeling, drilling, and other difficult problems.

The field of fluid dynamic modeling, known as computational fluid dynamics (CFD) is one of the most common supercomputer applications. This field could not exist without these machines because the simulations involve several complex coupled equations of fluid motion and mass conservation solved over millions of spatial points and speed is essential. Even today the equations are still unsolvable in their expanded form because the computers aren't fast enough. It has been projected that a computer 10,000 times faster than today's fastest is needed to solve the Navier Stokes equations. CFD has numerous applications ranging from aircraft and engine design to combustion to nuclear reaction simulation. These problems are just a few of the thousands which have been explored over the past four decades using supercomputers.

One of the most significant differences between the supercomputer and the PC is not its speed or memory, but the way the numbers are organized and processed. In the typical personal computer numbers are represented and processed as single variables. In supercomputers, disregarding memory organization, numbers can be stored and processed as vectors. A vector is a group of numbers related in some way, such as the weather condition at a certain altitude, latitude and longitude. Here the vector might have pressure first, temperature second, wind speed in the Z axis, Y axis, and then X axis for a total of five components. (Keep in mind, this is a very simplified view.) This entire vector can be called and processed, simultaneously, as one number. There are several methods of processing vectors currently employed by vector supercomputers. These include array processing, where the entire vector is operated on simultaneously, and pipelining, where each segment of the vector is operated on separately, in a stream. Using vectors makes addressing and retrieving much faster and the algorithms much simpler and more streamlined. A second place to look for speed in a supercomputer is in how the processors are set up.

Imagine having to prepare a casserole calling for four separate mixes to be combined in a single dish for baking. If you had only one mixing bowl you would prepare the first mix, pour, prepare the second, pour, and so on. This method, a serial method, is used in personal computers where only one processor is used. Now, say you had four mixing bowls and some help. You could prepare the four mixes at the same time and then combine them in the casserole. This second method is much faster and is used, in varying degrees, by parallel type supercomputers (the type being purchased by Virginia Tech). Instead of having one processor, you could have 100 working all at the same time. There are ranges of processor numbers. A moderately parallel computer would have four or 16 high-powered processors, but a massively parallel computer could have thousands of small processors. The IBM mainframe on campus is a former supercomputer consisting of four very large processors. Some parallel computers were made by connecting familiar Intel 286 chips (from decade old PC's) into a parallel system.



The increased speed is not created simply by the number of processors, but is also a function of the connections and how the memory is distributed. In a moderately parallel setup the processors would generally call from one central memory, but in a massively parallel setup this would be too slow and inefficient. Here there are small memories set up for each of the processors. In both cases this RAM is massive, totaling more than 1000 megabytes.

The large memory is needed because the problems being solved need extreme accuracy. Accuracy in computers is mostly a function of how much memory is allotted for the storage of the numbers. The more bits there are, the greater the resolution and accuracy. In supercomputers an integer, for example, can be stored in as many as 64 bits. A PC uses less than 32 bits.

The technology used in making the processors of a supercomputer enables them to be run faster. This technology includes the connection designs, the materials used, the manufacturing methods and the density of the chips. One of today's fastest supercomputers, the Cray Y-MP, has a clock speed of 2.1 nanoseconds. The clock speed is the time needed for one fundamental operation or instruction to be carried out. Relating this to PC's, the Cray Y-MP would be said to run at 476 megahertz.

As with any brief introduction to a whole new field, many questions probably linger. You've probably seen more of supercomputers than you think, though. If you're one of the millions who saw any recent high tech movie, including anything from Star Wars to Jurassic Park, you saw the complex 3-D animation and effects achievable only with the speed and power of supercomputers. So with the acquisition of the new machine this spring purchased with combined funds from the Computer Science, Math, and Biology departments, Aerospace and Mechanical Engineering, the University's Research Division, the Computing Center, and the College of Engineering, a new world of problems and questions only dreamed of by researchers will open up. EF

Facelift:

Former AgE department transforms itself into the new Biological Systems Engineering Department to meet changing needs.

by Ann Steedly

The Agricultural Engineering Department is giving itself a facelift this year. In order to keep up with the increasing worldwide focus on environmental issues, the department is changing its name to Biological Systems Engineering. Department Head John Perumpral warns that this change is not only cosmetic, but also involves a significant changes in program focus and specific curriculum requirements.

The name Agricultural Engineering often evokes images of farm equipment and growth-enhancing products such as fertilizers and pesticides. In the past, the department at Tech has focused on increasing production for the food and fiber industries.

According to Perumpral, agricultural engineers have served their purpose, enabling less than 2% of the current U.S. population to feed the country and produce food for export.

Along the way, however, the chemical products and farming methods used to maximize production and profitability have wreaked a great deal of environmental damage. Agricultural engineers must now prepare to deal with non-point source pollution and soil erosion cause by these production techniques.

Within the Agricultural Engineering department there are currently four options you may choose from in addition to a core that all must take. The machine and wood options are being fazed out of the program, but food will still be an option even when the curriculum restructuring takes effect.

According to Perumpral, 65% of students in the department currently take the land and water option. The land and water concentration focuses on control of pollution and conservation of resources.

Senior Christy Stoll says, "I chose the land and water concentration under the agricultural engineering department because the program deals with non-point source pollution and land erosion."

She plans to enter the field of environmental law and wants to have a strong technical background.

Stoll feels that the Agricultural Engineering department prepares students well for environmental careers.

"Students are very well-rounded, and have a strong computer background," Stoll said.

In addition to taking courses within their own department, students must take environmental courses under the department of civil engineering. A new course in Geographic Information Systems, a graphic program used by environmental agencies to link maps with corresponding environmental data, was introduced last year.

Many students also work at the Information Support Systems Lab, a GIS facility run by the department.

The change in the curriculum primarily involves an increase in emphasis on subjects the department already requires courses in. Currently, students take 14 hours of biology and chemistry.

Under the new curriculum, students will take 24 hours of biology and chemistry. A new course in non-point source pollution and the new GIS course are also part of the new curriculum.

Perumpral says that the new curriculum is focused on pollution prevention. "We must try to control and manage non-point source pollution and soil erosion. We must find out how we can avoid run-off," he said.

Controlling the damage after the fact he says often proves both difficult and expensive. The department conducts research on run-off at their rainfall simulator facility in order to develop equipment and management techniques that will control the run-off before it causes damage.

Though not an official change in curriculum, significant changes are taking place in the year-long senior design project. Seniors usually work on a project that the faculty is already researching. According to Perumpral and Stoll, each year projects deal more with environmental quality than quantity of production issues. This year faculty and students are researching a project in the area of bioconversion. Bioconversion involves the application of agricultural by-products to industrial applications. Cornstarch can be used in the

BIOLOGICAL SYSTEMS ENGINEERING

manufacture of biodegradable polymers. Ethanol can be produced from biomass and oil seeds are used to make lubricants. This year's senior design project requires that students come up with methods for utilizing the sludge produced in poultry processing. Stoll says that the major use students are researching is land application of the sludge.

Bioconversion allows agricultural engineers to address environmental issues while still focusing on supporting the farmer. These products open up profitable non-food markets to farmers who currently have low profit margins on their food products. As Perumpral says, "When you have these products developed you are going to improve not only the environmental quality, but also the economic vitality of rural communities."

With all of the new environmental focus in the department the name change to Biological Systems Engineering is simply the next logical step in a shift that began several years ago. The curriculum will continue to change and grow rapidly in the next few years. If you are interested in finding out more about this dynamic and vital field stop by the Department Office located at 200 Seitz. EF

Photo by Jessica Smothers

One of the main focuses of the new Biological Systems Engineering Department will be the preservation of the environment.

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Thinking about *over* -engineering

Monta Elkins suggests that engineers, when creating new designs, should try hard not to try too hard.

by Monta Elkins

I predict that Over-Engineering will become an important problem in the 90s and beyond. Many engineers will fall into the trap of over-analyzing problems or over-engineering solutions that have little market value. I experienced over-engineering first hand on the weekend following the big cold snap in January. While visiting my parents, I borrowed their vehicle.

I knew something was up when my Dad suggested that I wear rubber shoes when driving his pickup 15 miles to town. It seems that this truck has some very interesting features that are obviously the result of sophisticated modern engineering. At the time, I was awed by them, though now I think his truck is over-engineered. When creating your engineering designs, please remember these examples whenever you have the urge to over-engineer.

The first examples of sophisticated engineering were the child safety features. There was the Door Anti-Close Safety (DACS) feature. The door must be pulled up while closing with enough force (carefully calculated it seems) to be beyond the generation capacity of a small child. Most likely this feature was designed to keep children from becoming trapped inside the cab with no means of escape.

An obvious example of over-engineering (considering the DACS is already in place) is the air holes in the floorboard. These make sure that should a small child manage to defeat the DACS system and get trapped inside the cab of the truck, he or she would be assured of a good fresh-air supply. (These holes, in combination with the slushy road conditions, are the reasons my dad recommended the rubber shoes.)

There is also the Person Anti-Fallout Window Lock. This is carefully engineered to keep even larger children from falling out of a window by making it impossible for a large child to roll down the manually-operated window. I applaud this non-computer-controlled, non-electric, and therefore very inexpensive system. The only reason that I mention this highly-desirable feature in this article on over-engineering, is that it makes the window very difficult to roll down even for adults. It deserves more attention.

That brings us to the Secret Accelerator Position Anti-Start feature, which must have been engineered to keep unauthorized persons or children from starting the vehicle without knowing the precise, (secret) location where the accelerator must be placed in order for the vehicle to start. Knowing how far to push the accelerator is equivalent to a password on a computer system. I know first hand that any attempt to start the vehicle without knowing/finding this position will be unsuccessful.

Other examples of over-engineering became apparent after I had defeated all the safety-interlocks and was underway. There are several sophisticated features incorporated in the minimum engine RPM setting: Guaranteed Minimum Acceleration, Guaranteed Minimum Speed, and Reverse Engineered Low-Speed Acceleration Control (RELSAC) that requires using the brake for speed control at low speeds. I really don't have the expertise to discuss these systems in detail, but they seem to enhance safety by forcing the driver to maintain an adequate speed and adequate acceleration from stop.

The RELSAC took a little getting used to. When I pressed the Leg-Saver Soft Clutch in a poor attempt to defeat the RELSAC, it triggered a high-pitched whirring/whine alarm. So I opted to leave the clutch out and modify the Low-Speed Velocity Control with the brake, as per the RELSAC manual. (Actually I could not locate the RELSAC manual, but this is the only way it could have worked.)

Some of the features are so sophisticated they are beyond my grasp. The semicircular lines etched on the outside of the windshield are some sort of heads-up display unit, but I cannot figure out how they work. They may somehow be used to approximate safe following distances. I am somewhat offended that someone might think that I cannot judge safe following distances without assistance. This is a perfect example of over-engineering — designing features so complicated that even a person of my caliber cannot use them. Consider how much worse it must be for the average person.

> *This is a perfect example of over-engineering — designing features so complicated that even a person of my caliber cannot use them. Consider how much worse it must be for the average person.*

Some of the features are easier to comprehend. For instance, there is the Approaching-Speed-Limit Vibratory Alarm (ASLVA).

This ASLVA causes the driver to vibrate when the truck approaches 55 mph, alerting him to possible speed limit violations. This well-thought-out alarm could even be used by "challenged" drivers that are deaf or blind.

My dad is also a hunter and his truck reflects those interests. He started, a few years ago, studying how to reproduce the particular screech/squawk that a turkey makes. He uses all sorts of wooden hand-held chalk based resonators and even an intra-oral plastic device. I've often kidded him that if he ever hiccoughs when using it he'll talk like a turkey for the rest of his life. In any case, the truck has a very special feature related to his pastime. It seems that when in motion, the truck body has been finely tuned to mimic this squawking sound. I'm not sure how it does this, but I *am* sure that it attracts the attention of turkeys for miles around. How it accomplishes this without electrical modulation or even amplification is a small miracle of engineering. Generating such a specific sound out of the vehicle's motion and amplifying it with sheet metal is an amazing feat. Yet, somehow, it seems wasteful to spend so much engineering expertise on such a small market niche: turkey hunters.

Some of the features I know a little more about; I even know how they were produced. The special removable tailgate feature was created by precisely dropping a large cubic-inch displacement "Hemi" engine on it. The grill modifications were ingeniously made by striking a particularly large free-standing indigenous woody plant — repeatedly — at carefully-spaced intervals of weeks or months. A less sophisticated observer might have derided the striking of the same tree more than once as careless driving, but I recognize the advantage of continuous improvement and the superiority of modifications made through several iterations.

As a matter of fact, it has undergone so much modification that my Dad swears that it was created in 1985 or at least 1984, even though the door plate states it was manufactured in 1983. I don't remember it having all of these features when new. He could be right.

It has been suggested that this truck is over-engineered, not because of all these unique features, but simply because it can still be driven, and was not relegated to the junkyard years ago. My dad asserts that "some people just don't know how to appreciate a fine vehicle." Maybe so. EF

GLOSSARY

EE 2504 GLOSSARY (c) MONTA ELKINS 1993

COMPUTER ENGINEERING GLOSSARY

RISC — *Really Ignorant Stupid Computer.* Only supports very simple instructions.

CISC — *Complicated Ignorant Stupid Computer.* Supports more instructions than you can remember and leaves you wishing for less.

Grey codes — Binary counting method designed to change your hair color.

Karnaugh Map — A map used by geeks, thought to help them gain Karnaugh Knowledge.

Boolean — A label found on premium hamburger made only from bulls and designed to reduce the risk of heart disease.

Minterm — A carefully calculated quantity equal to the lowest possible final grade you can receive in EE 2504 and not become a candidate for academic suspension.

Digital Logic — Counting on your fingers. (See also Digital Computers.)

Binary One — A phrase sometimes used by farmers to describe their computer purchases. "I didn't bi-nary one."

Base 2 — How far you can run on a double.

Inverter — Common male goal with coed classmates.

Computer Architecture — The study of building things with computers. Ex: Making those cool aquariums out of monitors.

Flip-Flops — Sandals with two states: off and on.

Register — 1. What doesn't happen when you try to understand complicated computer design components. 2. What you had to do to take the class.

2 bits — 25 cents.

4 bit adder — Someone who can add up to 50 cents.

MUX — A device capable of turning many inputs into one tangled mess.

DEMUX — What your and your instructor try to do to your design project after you MUXed it up.

Decoder — A mythical solid state device that can turn your chicken scratch design into something brilliant.

Tie-to-one — Common EE misprint for "Tie-one-on."

RTL — *Register Transfer Language.* Ex. "Everybody put your *#%! hands in the air, and you put all the money in this bag."

Open Collector — The bag used in the RTL example.

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