Engineers' Forum

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Letter From the Editor

Hello fellow Hokies!

Midterms are scarcely over already finals are on the not-so-distant horizon! Alas the year is almost over and now is the time to stay on the ball and ride the year out with style. Whether you're an engineer or you just love the sciences, the Engineers' Forum hope to provide an interesting that gives you a break from studying, a new insight on a technology, or even a hint on your future career plans. Buckle up for a bite of the latest news on research and technology!

If you're a die-hard football fan, look to Nahu's article on the latest technology behind designing protection in Hokie helmets, and why research in sports safety has a bigger impact than what meets the eye. For the fans of nuclear technology, Susanna takes a look at one of the most interesting prototyping labs at Tech that develops fusion fueling technology as a unique energy source for the future.

Ben is back with a new section of "Warelab Correspondence"! Get the latest development from three of our teams and active coverage for several new engineering projects nearing completion. For the latest in student community and development, Vidya takes a look at Tech's InVenTs Community, and what it means to get an early start on team building and design skills in an academic setting.

If you consider yourself more a big picture engineer, turn to Joseph's behind-the-scenes look at how Tech cools an entire system of dorms and offices using chilled water air conditioning technology. Similarly Naomi dives into the biomedical field in a special look at current fertility technologies and what options new couples in the workforce may look to if they plan to start a family.

Just as the researchers and writers of the EF look to the future of technology, we hope you will take a moment as finals head your way to picture your future and reflect on the direction you would like to see your life take. There is always more to discover, and, whether or not it's our magazine that helps you along the way, we urge you to keep exploring! Thanks for reading!

Coleman Merenda

Editor-in-Chief

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Football, a Catch-22

By Nahu Dimitri, a sophomore biochemistry major

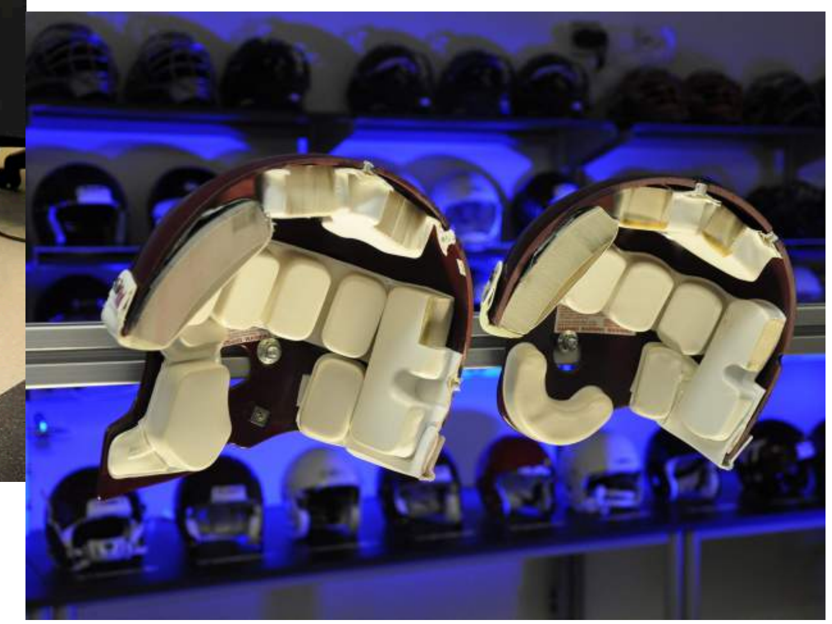
Dr. Duma testing the quality of concussion-prevention in a helmet

Following a hefty, $760 million lawsuit by former football players, the National Football League (NFL) has collaborated with researchers and taken the initiative on tackling head trauma. On the field, new rules and fines have been implemented in order to deter head-to-head collisions. Off the field, the league has committed $100 million towards the diagnosis, treatment, and prevention of player injuries, more specifically brain trauma. Although player safety and awareness are now becoming priorities for professional football, research institutions such as Virginia Tech have already made those issues their paramount concern. Before the NFL lawsuit and media attention to sports head injuries, the extent of how dangerous concussions are had been relatively unknown. Extensive research began to show that, through the years, violent blows to the head could lead to extreme behavior, mood swings, and other mental problems. Concerns were further heightened after the magnetic resonance images (MRIs) of two former NFL players that committed suicide showed chronic brain injury that may have been resulted from them playing football. The initiative has since been taken to understand what kind of damage can be done to the brain after contact, especially for youth players.

At the Virginia Tech/Wake Forest School of Biomedical Engineering, researchers are at the forefront of brain imaging and helmet research. Current projects include iTAKL, a study that uses multiple imaging instruments to observe youth football players helmets as they play and how head trauma can impact their developing brains. What sets this study apart from others is that data is collected throughout the year and not just the season. Research is not only being done to solve problems for the future; it is being done to create solutions for the present day.

The Summation of Tests for the Analysis of Risks (STAR) evaluation system is a ranking system used to determine the quality of concussion prevention in helmets. "Before this helmet rating system, no one knew which helmets were good to use and which weren't," said Dr. Stefan Duma, department head at the School of Biomedical Engineering. "We are developing ways of limiting head trauma, not just in football, but in other contact sports such as lacrosse and soccer." When asked about how a helmet company would respond to a poor ranking, Dr. Duma was quick to point out that safety is the number one priority: "Initially there were complaints about their product rankings, but eventually they conformed to our standards to avoid another poor grade." In fact, before the STAR evaluation system was unveiled, there were players on our own Hokie football team wearing one star rated helmets, the worst score a helmet could receive.

Football is the most popular sport in America for a reason we often fail to admit: its violent nature. Much like the crowds that flooded the Roman Colosseum, spectators take pleasure in watching larger-than-life figures battle amongst one another, but football has its own Catch-22. The sport is now at a crossroad between glamor and safety; more rules and fines are being enforced to ensure the game is safer to play, however complaints have been rising that football has become "too soft" or is "just not the same game." By making the equipment smarter, engineers are preventing bureaucratic alterations to the game that could damage the league's profitability and popularity.



2014 helmets

The game has been made safer thanks to the work being done Dr. Duma and his phD candidates"

Why is it so Cold in This Class?

By Joseph Davis, a senior mechanical engineering major

An outside view of chilled-water plant. The cooling towers can be seen on the top of the building.
Photo Source: University Design & Construction Department.

View of piping system just above chillers. Labels indicate the type and direction of water in the pipes.

After a historically brutal winter, warm weather is finally starting to make its way to Blacksburg. As a result, many members of the Virginia Tech community can be seen sporting shorts and T-shirts. In response to this, the people who are in charge of temperature control decided it was necessary to drastically reduce the temperatures in classrooms so that students could experience winter weather every day of the year. After all, "what's cooler than being cool?"

Before you sign your complaint letters to the new Virginia Tech president, take a moment to appreciate the magnificent, yet sometimes oppressive, feat of engineering called air conditioning.

Just from examining the name itself, we know that it is a method used to condition air to certain specifications. The number one specification in this case is, of course, cooling. You may have noticed, while parking at the last available spot on campus, that there is a new building at the back end of "the cage" parking lot. This building is a new chilled-water plant with a simple function: providing air conditioning to the Virginia Tech campus. While there are other chilled-water plants on and around campus, this one went online last summer to support current and future campus growth.

In a typical air conditioning system, cold refrigerant is passed through series of coils inside building ventilation systems. These "cold coils," as they are often referred to, combine with a blower to make up an air handler, which exists in just about every building. When hot air passes over the coils, the air is cooled down as heat passes from the air to the refrigerant within the coils. The cool air is then blasted through the building and out of the vent directly over the desk you decided to sit in.

All of a sudden, wearing flip flops to class seems like a bad idea.

Typically outside the building, a condenser (one of those loud cubical devices that sits on your lawn and really doesn't match the tulips) cools down the heated refrigerant by using a fan, compressor, and "hot coils" (same as "cold coils" but air is heated rather than cooled as it passes over the coils) to release the heat into the atmosphere. The recooled refrigerant reenters the building and the cycle starts all over.

In a chilled-water air conditioning system, much of the process is the same. However, instead of refrigerant being pumped through coils to cool down the air, chilled-water flows through the coils. Chilled-water air conditioning is more economical for large-scale applications, such as campuses, urban areas, or industrial plants because water is cheaper than refrigerant.

In the Virginia Tech chilled-water system, cold water is pumped through series of coils inside a building's air handler. Air is passed over the coils and distributed throughout the building. The heated water from the air handler is pumped from the building to the chilled-water plant and enters chillers within the plant. These chillers act as large-scale, less-exciting refrigerators. The heated water exchanges heat with cold refrigerant within the chiller. The water, now cooled, then returns to the campus buildings to restart the process. This water loop (from campus to the chilled-water plant and then back to campus) is called the chiller water loop. In the picture that shows the intricate system of pipes within the chilled-water plant, pipes labeled CHWR (chiller water return) or CHWS (chiller water supply) indicate a pipe which is part of the chiller water loop. "Return" means the water is traveling from campus to the chilled-water plant and "supply" means the water is traveling from the chilled-water plant to campus.

It is easy to understand the chilled-water system if you imagine two system loops. The first is the chiller water loop, as described above, and the second is the condenser water loop. In the same picture which shows the system of pipes within the plant, pipes labeled CDWR (condenser water return) or CDWS (condenser water supply) indicate a pipe which is part of the condenser water loop. The function of the condenser water loop is to release heat collected by the chiller water loop into the atmosphere. The water in the condenser water loop is minimally treated and is pumped through the chiller and collects heat from the refrigerant. The water then travels to a cooling tower (located on the roof of the chilled-water plant) and heat is released to the atmosphere. In the cooling tower, a large fan sits at the top of the tower and blows air upward into the atmosphere. Beneath the fan, water is sprayed and allowed to free fall downward as air is pushed upward, cooling the water and releasing the heat into the atmosphere. This cooled water is then pumped from the cooling tower back down into the chiller to cycle back through the condenser water loop.

In summary, the chiller water loop consists of the air handlers in campus buildings and the chillers at the chilled-water plant. The condenser water loop consists of the cooling towers on the roof of the plant and the chillers on the first floor of the plant. The loops connect and exchange heat at the chillers through cycled refrigerant.

And that's how it works. So next time you're sitting in class using the heat from your laptop to warm your hands, remember that it's all thanks to good old technically-minded innovators like yourself. While you're at it, give yourself a pat on the back.

You stay cool, Virginia Tech.

Actually, don't. Please, for the love of all things holy, lower the AC.

The accurate information in this article has been provided due to the generosity of two Virginia Tech HVAC senior technicians: Jason Pearman and Jimmy Doss.

Fusion Fueling at Virginia Tech

By Susanna Mostaghim, a sophomore math and statistics major

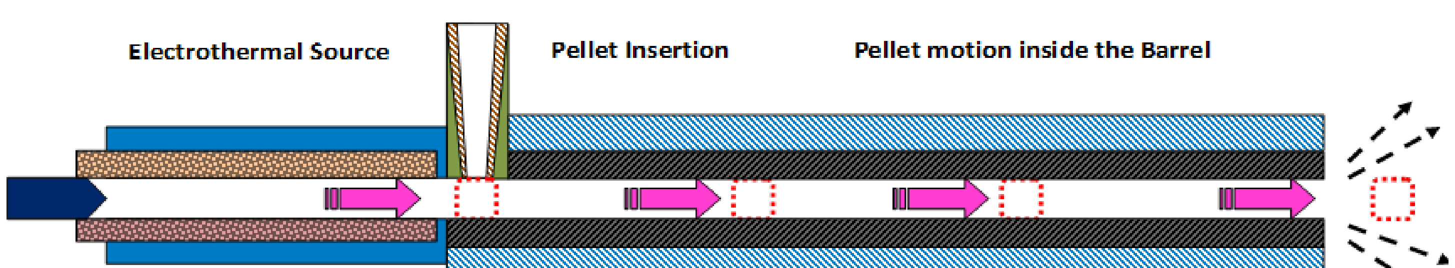
When people hear the word nuclear, they usually experience a feeling of apprehension and nervousness; events such as Three-Mile Island, Chernobyl, and Fukushima have primed almost everyone's subconscious to associate nuclear energy with danger and risk. However, that does not stop students from working on nuclear engineering research here at Virginia Tech. Inside Dr. Leigh Winfrey's Innovative Science of Ionized Species (ISIS) Lab in the newly re-established Nuclear Engineering Department, one of the main projects being worked on is fusion fuelling with a tokamak system. The project is being led by doctoral student Trey Gebhart.

A tokamak is a device that uses a magnetic field to contain plasma in the shape of a torus produced by electromagnets surrounding the torus. It induces a current using a second set of electromagnets. It is one of the most-researched candidates for thermonuclear fusion power. The magnetic field is used for confinement since no solid material can withstand the extremely high temperatures of plasma. Gebhart chose the tokamak over a stellarator, an older device that also uses magnetic fields to sustain a controlled nuclear fusion reaction. Since the 1990s there has been renewed interest in the stellarator in the nuclear community, after it fell out of favor to the tokamak in the 1970s.

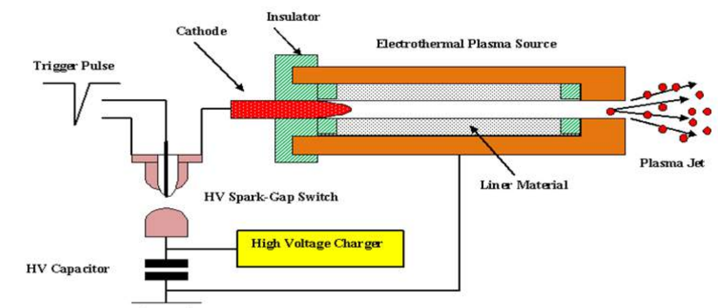
While working on his thesis prior to becoming a doctoral student, Gebhart used a simulation program to show how the tokamak system would react to different parameters, thereby changing pellet exit velocity, called et_flow. The velocity depends on pellet size, capillary length, and current (in kA). He and fellow graduate student Micah Esmond have written several papers using results from these code runs about tokamaks and fusion fuelling. Pellet exit velocity has been shown to have a maximum of 5 kilometers per second (kps) when given a maximum voltage of 10 kV and up to current of 100 kA.

Currently, he and several undergraduates are building an electrothermal plasma pellet launching system, called Sputnik, a joking reference to its likeness to the satellite. This system is a high vacuum environment that allows for electrothermal plasma to remain in a near-ideal system by removing the chance of propulsion gas (a plasma poison) that could enter the system in the current two-stage light-gas gun that is used. This will enable them to achieve better, higher speeds. This system will shoot deuterium and deuterium tritium pellets to increase number density (fusion rates) in a tokamak fusion reactor; however, plastic pellets are being used at the current time. Gebhart says that these cryogenic pellets are shot at 14 Kelvin into a tokamak reactor containing plasma that is "hotter than the surface of the sun".

By employing a high-vacuum environment for electrothermal plasma diagnostics, the group working on fusion fueling inside ISIS is trying to maximize plasma temperature and density, increase bulk velocity, and observe plume composition and shape, as well as pellet speeds for different source sizes and discharge currents. These currents range from 10 kA to 40 kA. The source size's capillary length ranges from 0.075 m to 0.12 m, with the best velocity occurring at the 0.105 m length for both pellet sizes. By maximizing these speeds to 5 kps, fusion fuelling's efficiency is increased.



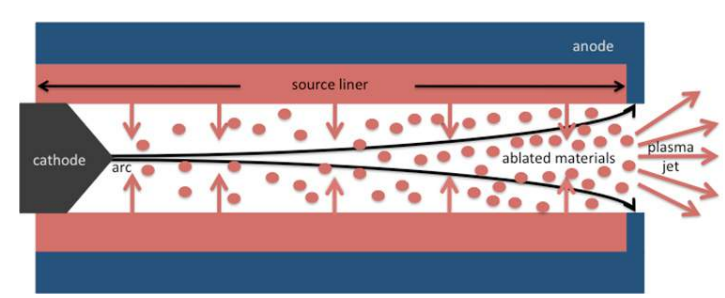
A look at the propulsion sequence that sends the cryogenic pellets into the plasma inside the chamber.



A look at the trigger for the system at the source for the system.

The source is where the plasma forms. It consists of ground housing, a sleeve, electrode, flange, feed-through, and an insulator. Once the voltage is pushed through the cathode past the insulator into the source the electrons rush through the source liner and ablate the materials through ionization. From this process, a plasma jet forms at the end of the source where the pellet has been inserted beforehand. From there the pellet moves through the barrel of the launcher and is launched into the tokamak chamber. The chamber and barrel are both inside a high vacuum, which is created by a vacuum vessel, in order to remove effects from contaminants that could be in the air, or other disturbances in the environment.

While the hope for the system is that it will be modular enough to encompass most experimental projects in the ISIS lab, the project is still only in the design phase; the pellet-measuring chamber extensions, barrel segments, and electrical system are both in the works. However, a component, the source, is done and waiting for materials to be selected, while the chamber stand is being made. When the components have been machined and assembled, it is hoped that the fusion fuelling experiments will be successful and that all of the goals for the system will be achieved.



Electrons flow through the source to ablate the materials to create the plasma jet that powers the pellet.

Biomedical Engineering Advancements on Infertility Research

By Naomi Butler-Abisrror,
a freshman general engineering major

Women are born with approximately two million ovarian follicles. Throughout a woman's lifetime, these follicles are either reabsorbed into the body, or released through menstruation until they are completely exhausted and the woman has reached menopause. Menopause signals the termination of the reproductive stage in a woman's life. Due to changing roles in the home and the workplace, women today are choosing to have children much later in life, specifically when they feel that they are both financially and professionally stable; however, the biological clock waits for no one. While women continue to work and become more established in their careers, this inexorable clock continues to tick; each minute forebodingly representing the impending arrival of infertility.

The advancements that have been made in the biomedical engineering field in the past few decades have been astonishing in their scope, implication, and applicability to the modern world's medical problems – including infertility. A lot of research has been, and is currently, being done on ways to overcome the infertility issues that many women face. Many of these issues are the result of a congenital condition, an ovarian disorder developed later in life, or the natural occurrence of menopause.

The most well-known assisted reproduction technology today is the one used during in vitro fertilization (IVF). During in vitro fertilization, women prepare their bodies by undergoing hormone consumption in order to create a more appropriate environment to encourage the development of eggs in ovaries. The final maturation of the eggs is induced by an instrument that inserts more hormones into the body. A doctor lightly sedates a woman in order to insert a needle into the woman's ovary and extract eggs from the ovarian follicles by watching a real-time ultrasound visual of the procedure. The eggs are then taken to the laboratory and fertilized by the winning sperms from a flask of washed, concentrated sperm. The newly formed embryos are reinserted into the fallopian tubes in the hopes that at least one of them becomes a pregnancy.

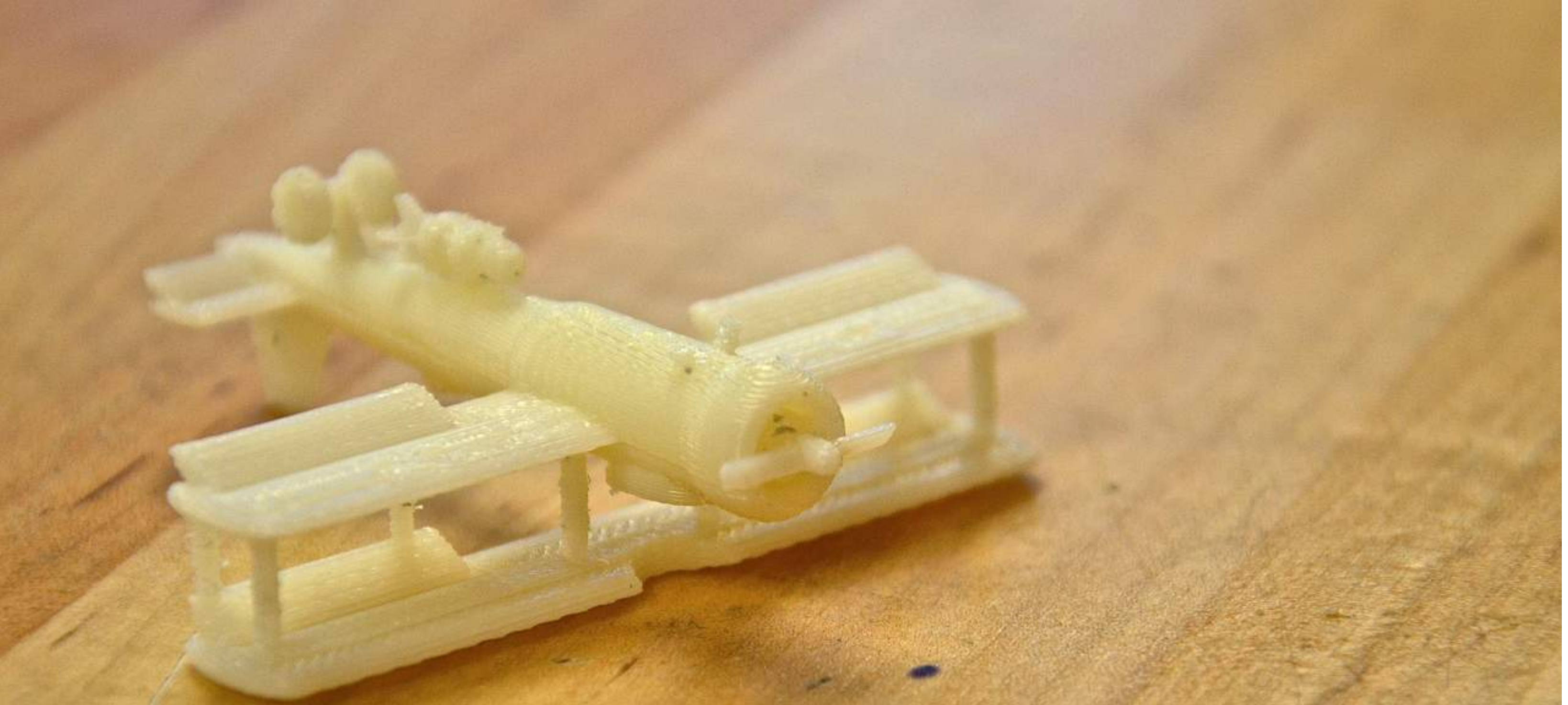
A second well-known, though not as widely used, method involves a gestational carrier – otherwise known as a surrogate. At times, the problem of infertility does not lie in the inability of the eggs to reach full maturation within a woman's ovaries; it could be due to a condition much more difficult to deal with such as a fallopian tube blockage or a debilitated uterus. In either case, a pregnancy either cannot develop or, when it does, it usually results in a miscarriage. The purpose of surrogate mothers is to pose as the carriers of the babies. These women carry the embryo formed by the real mother's egg and the father's sperm. Their job is to ensure that the baby being formed within them is carried full-term without the complications that the biological mother would face. The procedure for inserting the embryo in the surrogate mother is similar to IVF.

For women who do not have any infertility disorders and would like to wait until later to have children, but fear exposing them to the risk of developing chromosomal defects that come about from utilizing aged ovarian eggs, vitrification is a viable option. The idea of vitrification is that a woman's young eggs can be made into embryos and cryogenically preserved by freezing them for later retrieval. This is most likely to be when the woman decides that she is ready to mother a child. One of the risks involved with this method is the formation of ice crystals that damage the embryo. However, with the application of a high-concentration antifreeze, the temperature drops rapidly enough that the embryo has no time to form harmful intra-cellular ice crystals and can be preserved for decades. This genetically intact embryo results in a healthy child.

If the current treatments available are not impressive enough, the ongoing bioengineering research on infertility is even more fascinating. Similar to vitrification, ovarian tissue grafting is emerging as another possible way for infertile women to conceive. The procedure involves slicing out pieces of ovarian tissue from a woman while she is still young, and having this tissue preserved for her should she need it in the future. This is done in case she was to ever develop some unexpected form of infertility. For instance, if a woman suffered from cancer at some point in life, the chemotherapy treatment she would undergo would damage her ovarian tissue cells, rendering her infertile. By reinserting the slices of ovarian tissue that were extracted from her years ago at regular intervals, the functionality of her ovaries can be restored.

Lastly, the most groundbreaking finding in biomedical engineering research for infertility revolves around overthrowing the established dogma that women are born with a finite number of eggs. Jonathan Tilly, a reproductive biologist at Harvard Medical School and Massachusetts General Hospital, and his colleagues investigated the possibility that mammals can replenish their bank of eggs throughout their lifetimes as other species seem able to do. By experimenting with mice they found that, although there was a steady decline in egg count, as is already known, the rate at which the egg count was being diminished was one-third of the total egg count, and there was no possible way that eggs could last more than a few weeks. This could only mean that the supply was somehow being replenished. In a novel venture to prove that a stem cell involved in the generation of these eggs existed, Tilly genetically engineered mice to contain fluorescent jellyfish genes. He inserted ovarian tissue into these mice. If his theory was correct, new green eggs would be formed by these theoretical stem cells on the newly inserted tissue – and that was exactly what happened.

Because the current methods for treating infertility actually bypass the problem rather than solve it, there is still a lot of progress to be made. But with current research findings that defy the basic principles of reproductive biology that engineering innovation has come to work around, more promising, trailblazing techniques are surely underway.



InVenTs Living Learning Communities: Paving Paths to Engineering and Scientific Success

Vidya Vishwanathan, a freshman general engineering major

A model airplane printed by an InVenTs student using the 3D printer located in Studio 1 of Lee Hall.

Virginia Tech's Lee Hall is home to the campus' InVenTs communities, and is constantly flowing with ideas for "re-inventing the future." The InVenTs organization at Virginia Tech consists of four living-learning communities: Curie, Da Vinci, Galileo, and Hypatia. These communities share the common objective of "imagining, discovering, and creating the future." InVenTs is a leeway for freshman engineering, science, and math students to ease themselves into the college experience, as well as find peers who share a common interest in their respective fields of study.

The InVenTs organization began 13 years ago with the Hypatia living-learning community. Dr. Bevlee Watford, director for the Center for Enhancement of Engineering Diversity (CEED), saw that women's representation in the engineering field was not as high as it could be. "InVenTs was like Dr. Watford's baby idea. It originated from her," said Susan Arnold-Christian, assistant director of CEED. Currently, Hypatia boasts a 90% retention rate of females who continue to pursue a degree in engineering versus 72% for females who started as engineers, but were not members of the community. In fact, although InVenTs was originally designed for freshman, student members quickly developed a close attachment to the community and persuaded Dr. Watford to extend the program to include the undergraduate engineers who wanted to continue living in the learning residences.

It is often joked among the InVenTs community that the Galileo men's engineering living-learning community developed as a result of the male engineers becoming jealous of the opportunity that the women had with Hypatia. Da Vinci, the Biological and Life Sciences Learning Community, was started by the Virginia Tech Department of Biology and Dr. Jill Sible. Its purpose is to establish an interactive community where biology and life science majors could receive an extra boost to succeed in their science courses. The most recent addition to the InVenTs family was the Curie Community. It began in the fall semester of 2012. This community is designed to focus on students majoring in the physical and quantitative sciences.

Each community has a mentoring program in which an upperclassman mentor is paired with several freshman students to offer advice and provide support as the freshmen ease themselves into college. Along with the mentoring program, there is a weekly seminar in which students learn professional development skills and tactics in order to make good impressions during job fairs such as the Engineering Expo, or to have a successful interview with a potential employer. The mentors are also members of social, academic, service learning, or professional development committees who are responsible for planning events such as milkshake socials, chemistry and physics review sessions, and community volunteering opportunities. The committees allow InVenTs students to voice their opinions and become engaged within the community.

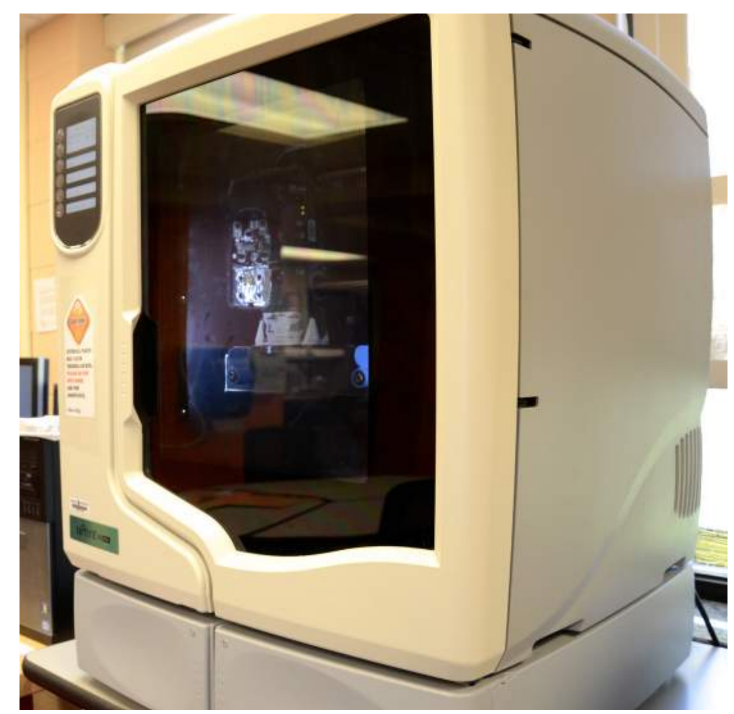
One of the many traditions in Lee Hall is the Slush Rush. Every Friday, a local engineer, scientist, or a Virginia Tech faculty member speaks in the casual environment of the Lee Hall second floor lounge to present a synopsis of their research or to showcase their occupation while acquainting themselves with the students in the community and slurping freshly made slushies. In accordance with Virginia Tech's motto Ut Prosim, over 100 InVenTs students partake in the annual fall leaf raking tradition and help rake the fallen leaves around the Blacksburg community. One of the more recent InVenTs customs is the Neon Nights dance. It is a 90s-inspired event where students from all four communities have the opportunity to make new friends and enjoy music from the previous decades.

Studio 1 is one of the defining, and most loved, parts of the InVenTs community. Resources such as the 3D printer, laser cutter, drill press, milling router, and power tools are available to the students, in addition to graduate advisors who help make the students' ideas a reality. Nikki Lewis, one of three InVenTs Studio supervisors said, "It is so easy to be creative with so many resources in this space. We are able to teach the students real world skills, and they seem to enjoy that." Studio 1 is also a place for companies such as Lockheed Martin, Orbital Sciences, Altria, and Google to teach students to program with Arduino boards, launch rockets, or design their own apps. When asked about what aspects of Studio 1 appeal to her, Genevieve Gural, a freshman general engineering student in Hypatia said, "I love the fact that I can literally walk downstairs and use some insane equipment like the laser cutter and 3D printer. Even better, I get to hang out with the InVenTs staff members, who are the coolest people I know!"

The InVenTs community has earned a reputation of being more than just a living-learning community. Many students return for their second or third years of college to experience the great benefits of being in the Hypatia, Galileo, Da Vinci, or Curie communities. "The organization runs on student ideas. We give great importance to our members' voices," said Arnold-Christian. In fact many of the events such as the Slush Rush, outreach, and social activities in Lee Hall have been the result of ideas contributed by undergraduate students at the member meetings. Soon to be the home of over 800 members, the InVenTs community continues in its endeavors to promote the growth of the science and engineering communities.

When asked about the ultimate purpose of the InVenTs community, Susan Arnold-Christian replied, "We want to get these students of different disciplines engaged and working together on projects and learning the way each other thinks. Very few times in real life, in the workforce, do you see engineers who only work with engineers or scientists who only work with scientists, so we really want to give the students an early taste of what that feels like, and I think we have been quite successful."

An inside view of the InVenTs Studio laser cutter while it is open and being calibrated to cut a design on the wood. The small red light seen in the upper left corner of the wood is the laser being positioned to cut in a precise location.



The InVenTs Studio 1 3D printer currently in process of printing a student's design.

Ware Lab Correspondence

Hello Readers!

It's the most wonderful time of the year: competition season at the Ware Lab! Continue reading to learn about the VT Hybrid Electric Vehicle Team, VT Baja SAE, and Astrobotics, as well as what progress each team has made towards completing their respective projects!

Hope you enjoy,
Ben Gingras

Hybrid Electric Vehicle Team (HEVT): Going for Green

HEVT at a Glance:

Project Stage: Refinement
Competition Date (3rd and final of 3 year EcoCar 2 Challenge): 6/1/2014
Location: GM Proving Grounds, Milford, MI and Department of Energy, Washington, DC

On Monday December 9, 2013, I attended HEVT's final design review. There was a general bustle in the room as the underclassmen team members, graduate student team leaders, and review panel took their seats. The seniors who were getting ready to present stood at the front of the room with confidence, awaiting the start of the presentation. I sat in the back row. Eli White, graduate student and co-lead of HEVT with Chris Manning, exchanged the following dialogue with another team member as he passed in front of me on the way to his seat:

"Ask them really tough questions," Eli said.

"What? Like 'will the car fly,'" the HEVT Member asked.

"No, seriously, ask them that. We've got the whole underwater thing worked out, but the flying part…."

While clearly said in jest, I found this exchange illustrative of the kind of high expectations that are held of the HEVT members, and of the project overall. Towards the end of the presentation, I half expected the car to be able to fly or dive myself; the scope of their project seemed so ambitious! The team's five central guiding goals for their reengineered design of the competition-provided Chevy Malibu aim to reduce both petroleum energy usage and greenhouse gas emissions while maintaining safety, performance, and consumer acceptability. In order to work towards these ends, the inner workings of the Malibu have been vastly redesigned. In the rear of the Malibu, the team has installed a lithium-ion battery pack beneath a removable trunk compartment. In addition to this, there is a rear traction motor and a single speed transmission. Under the hood of the car, the team installed a 2.4L E85 (85 percent ethanol and 15 percent gasoline) engine connected to a P2 generator motor, which is in turn connected to a multi-speed automatic transmission. "P2" stands for 'position 2,' meaning the motor is in between the combustion engine and transmission. It was developed by HEVT in collaboration with Kollmorgen and is central to HEVT's EcoCAR driving capability.

Like the previous EcoCAR challenge, the EcoCAR2 challenge is being held in three stages over three years. This is an emulation of the way General Motors (GM), a major sponsor of the competition, designs its vehicles. Manning explained that, "By the end of year three, the vehicle should be at 99 percent production quality." This means that it should appear and perform as if it had practically rolled out of a GM factory. This is year three for HEVT's Malibu, and competition is fast approaching. I checked back in with the team during the first week of March. As of this week, they are preparing to pack up the Malibu and ship it out to the Transportation Research Center (TRC) in Ohio for emissions and general performance testing prior to competition this June. One of most important items left to be crossed off the checklist while they are at the TRC is to finalize the integration of the team's controls system with all of the various components of the car.

The control system for the car is the algorithm that manages all of the processes which allow the car to be a hybrid and is comprised of two main modes: charge depleting and charge sustaining. When you first roll out of your driveway in the HEVT Malibu, the car is operating in what is called the charge-depleting (CD) mode. In this mode, all of the energy used to drive the car comes from the lithium-ion battery pack. The battery pack powers the rear traction motor which engages the rear single speed transmission. When the batteries begin to run low, the car's control system switches to charge-sustaining (CS) mode. In CS mode, the energy to propel the vehicle comes entirely from the 2.4L E85 engine. However, there are two additional modes within CS mode; series and parallel, which differ in how they deliver energy to the wheels.

In series mode, the multi-speed transmission in the front is set to neutral. The mechanical energy output by the 2.4L E85 engine is converted into electrical energy by the P2 generator motor. This energy is then routed to the rear traction motor, and the rest of the process occurs exactly like it does in CD mode; the rear traction motor engages the rear single speed transmission, propelling the car forward with rear-wheel drive. In parallel mode, the 2.4L E85 engine provides power to the front wheels directly through the multi-speed transmission. The control system for this vehicle is smart enough to sense various vehicle parameters and decide which mode is best for the situation at hand. So while it cannot be definitively stated that series mode is exclusively best for city driving, or parallel mode is always best for highway driving, this tends to be the case in general.

In terms of integrating this control strategy with the rest of the car, all of the components have been tested independently, but some have yet to be tested together as a system. For example, as of the first week of March, the engine has been tested successfully on a test stand but remains to be tested in the Malibu. Manning explained that for this week, a major goal is to get the engine working with the CS mode in the Malibu prior to being shipped off to Ohio. The hope is that doing so will ensure that the Malibu's time at the TRC can be used most effectively to gather test data of the entire car so that any necessary tweaks or bugs in the system as a whole can be addressed prior to competition in June.

After HEVT is satisfied with the emissions data it receives from the TRC, they will be on to competition in June! First, the team will compete in Michigan, where the Malibu will be scored on performance and emissions tests. Then they will move on to Washington D.C., where they will present their work to industry judges.

To learn more about HEVT, visit : http://www.me.vt.edu/hevt/. You can also follow them on Twitter (@vthevt) and Facebook (Hybrid Electric Vehicle Team of Virginia Tech) too.

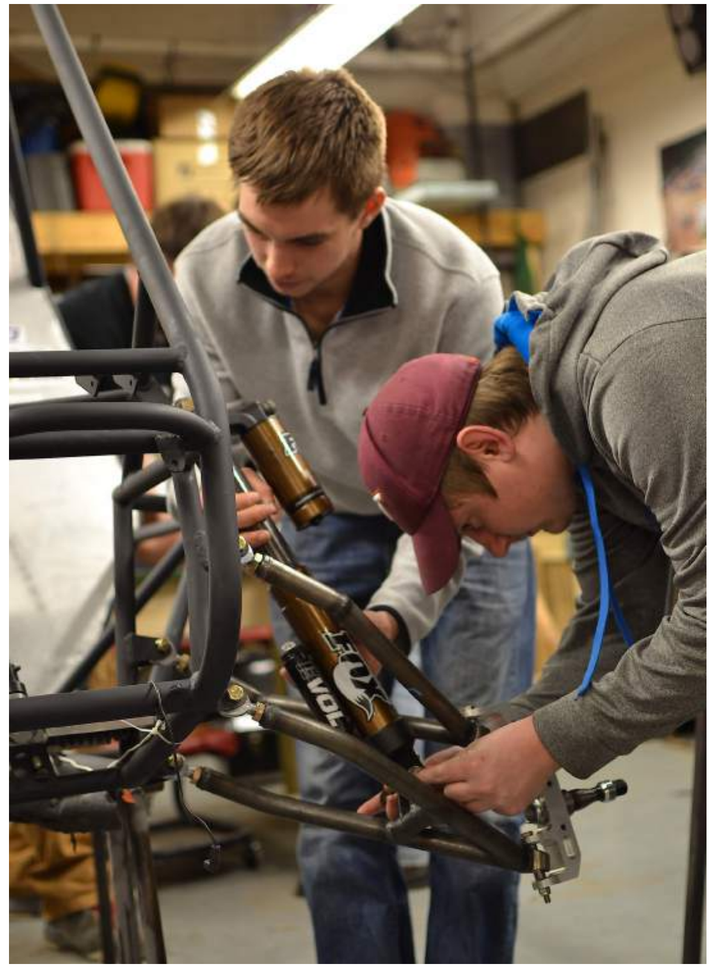
VT Baja SAE:
No Road, No Worries

Baja SAE at a Glance:

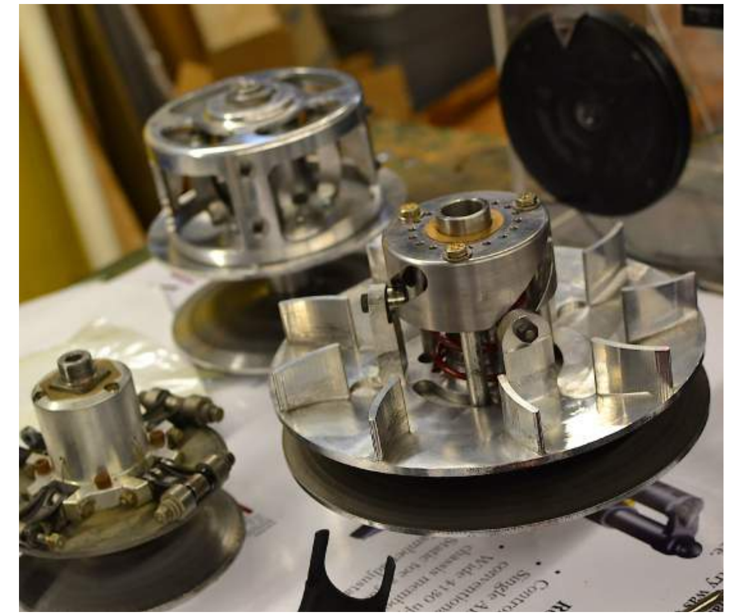
Project Stage: Revamp/Refinement
Baja SAE UTEP: 04/24/2014
Location: UTEP, El Paso, Texas
Baja SAE Illinois: 06/04/2014

VT Baja SAE is faced with the annual challenge of designing a high performance off-road race vehicle. Jaime Dorfman, co-lead of Baja SAE along with Curtis Long, informed me that the central binary inherent to this challenge is designing a vehicle that is as light as possible versus designing a vehicle for maximum durability. However, as senior team member Robert Romano explained, "You simply can't design for all the failures that crop up. For example, you can't design specifically for a head-on collision with a tree." This comment led to a discussion about what Dorfman and Romano called "overdesigning," an engineering philosophy by which the optimized design for a part or system may not be the best practical choice in application. An optimized A-arm, for instance, may be the lightest part that still meets the team's target performance metrics. Yet it could still fail during competition because of the unpredictable demands of an off-road competition. Overdesigning calls for the designer to take the performance metrics that he or she thinks is needed for a part, increase them by a magnitude of four or five times their original values, and then redesign the part in question so that its new geometry satisfies the new performance metrics. This alone is one of VT Baja SAE's best defenses against the accursed metaphorical tree.

Having just returned from the 2013 Winter Baja race held at Michigan Technological University, VT Baja SAE is currently in the process of deconstructing, tweaking, modifying, repairing, and reconstructing its off-road vehicle for the two other competitions it has scheduled in the coming months. They are addressing problems encountered in their steering system during the race, as well as some oil leakage coming from their gearbox. Nevertheless, over the course of my correspondence with them, these minor blemishes have been removed from the face of an otherwise spectacularly designed vehicle. As opposed to last year's Baja car, which sported a stock continuous variable transmission (CVT), the 2014 car houses a custom designed, student-fabricated (from scratch) CVT.


Baja SAE members hard at work connecting the shocks to the chassis above and the lower A-arm below.

The new CVT exhibits several major improvements over the previous stock CVT, mainly in its anticipated longevity and range of torque outputs. Romano, who took the lead on both its design and manufacture, explains that the new CVT was designed to last. Its bushings, the parts in both the CVT's primary and secondary that serve as the housings that enclose the shafts protruding from the motor and gearbox, are made out of oil-impregnated brass. The shafts themselves are hexagonal, as opposed to the standard square design, allowing for more surface area contact between the shaft and bushings. This arrangement will result in less mashing in the primary CVT than was observed in that of the stock transmission. In another effort to reduce mashing, the CVT's secondary was manufactured with steel ramps as opposed to aluminum. An enclosing cover was fabricated to protect the belt inside the CVT that runs around the primary and secondary. It will prevent dirt and debris kicked up during competition from gumming up the works inside the CVT. Moving beyond durability, this new transmission is beefed up; it is literally oversized, so much that it delivers a greater range of torque and greater efficiency (80 to 85 percent). Dorfman explained that last year's car did well in the low-torque events, such as the sled pull and the maneuverability testing, but scored poorly in the high-torque events, such as the endurance and acceleration testing. It is hoped that this custom-made CVT will allow Baja SAE to take home the gold in both low-torque and high-torque events because of its greater range.


Baja SAE's new student-designed and fabricated CVT. Front Right: CVT secondary that connects to the gearbox. Back Left: CVT primary that connects to the combustion engine. A belt will run through the primary to the secondary. Front Left: Sto ck CVT primary.

Further design improvements were made to the car's stability by tweaking the suspension configuration. Last year's car, named .38 Special, was one of the fastest Baja cars the team has built with a max speed of 31 mph, but it experienced a lot of body roll when going around turns. This year's team reduced the new car's excess body roll by redesigning the shocks so that they connect to the lower A-arm rather than the upper A-arm. Last year's team had the shocks connected to the upper A-arm in order to make designing and implementing the steering system easier. They did this because the shocks and steering can mutually interfere with one another if a shock to lower A-arm configuration is not designed with care. This challenge reappeared when the decision was made to go with a shock to lower A-arm configuration on the 2014 car, but this year's Baja SAE decided that it was worth the extra design effort to reduce the body roll.

If this article piqued your interest, visit: https://sites.google.com/site/vtbajasae/home. Or better yet, attend one of Baja SAE's meetings. They meet for class on Tuesdays and Thursdays at 9:30 am in Randolph 116. Just from interviewing them, it is apparent that they are a real friendly bunch. Plus, everyone participating on the team gets to drive the car. So check them out!

VT Astrobotics:
Designing a Real WALL-E!

VT Astrobotics at a Glance:

Project Stage: Design/Preliminary Testing
Competition Date: 05/21/2014
Location: Kenneday Space Center Visitor Complex, Florida

Asteroids, rovers, and mining – oh my! VT Astrobotics, formerly known as Lunabotics, is a group with a really cool combination of engineering perspectives, even with respect to other teams participating in the unique NASA Robotic Mining Competition. As it was explained to me, most other teams are solely mining engineers, or solely mechanical engineers, and this fact is reflected in their project designs. VT Astrobotics, on the other hand, has a confluence of aerospace, mechanical, electrical and computer, and mining and minerals engineering majors, with a sprinkle of economics majors to keep the books straight and team finances in the green. The team is divided into three sub-teams: Wheels and Drivetrain; Chassis, Bucket, and Mining Mechanism; and Programming, Power, and Autonomy.

As you may have picked up on, the central problem that VT Astrobotics seeks to address is space mining! The design context last year was mining on the moon, hence the team name "Lunabotics." This year, the challenge is to design a rover that can mine in a Martian or asteroid-like terrain. The competition space will be bounded by a seven meter long rectangle. In the center of the rectangle, extending to its bottom and top edges, there will be an obstacle field comprised of craters, hills, and valleys for the rover to navigate. The mining area will be on the other side of these obstacles. The task of the VT Astrobotics rover will be to navigate the terrain through the obstacle field, mine the most amount of regolith possible, and return the material to a collection station on the other side of the obstacle field. The team will have two 10-minute attempts to complete this extraterrestrial gauntlet. What is regolith you ask? Regolith is a low density "fluffy" sand that closely simulates the stuff you would find on the surface of Mars or an asteroid. Due to its low density, regolith is easily kicked up into the air. Consequently, in addition to how much regolith the rover mines, the rover will also be scored on how little dust it creates during operation.

Speaking of scoring, the competition is point-based. In addition to how much regolith the rover mines, and how little dust it generates in doing so, the rover earns points for passing initial inspections, reporting its energy consumption, exhibiting a dust-tolerant design, and operating autonomously (with different point amounts awarded for different levels of autonomy). Additionally, the rover loses points the greater its mass and the greater the average bandwidth it uses.

The team's design for the rover consists of a central chassis on which four wheels will be mounted. Adhemar Rivera, team lead of VT Astrobotics, explained that a significant amount of research was devoted to studying the wheels implemented in actual rovers for extraterrestrial navigation. This is understandable, considering that the past has taught us that billion dollar projects can easily go to waste if they get stuck in sand on a distant world, as was the case with NASA's Spirit Rover on Mars. The team examined the wheels implemented on the NASA Mars Explorer Rovers, the Russian Lunokhod Rover, and the lunar rover wheels developed by Michelin Tweel, among other sources for inspiration. Four design options for the wheels were generated, however, a simple fiberglass tube casing design was selected. There will be grousers, or small ridges, on the outer surface of the wheel to increase traction. The team did some preliminary testing and found that there was a constant increase in torque after 24 grousers were implemented. As a result, I suspect that the final wheel design will have greater than or equal to 24 grousers. Additionally, preliminary testing conducted by Astrobotics revealed that grousers of lengths between 10 and 30 mm produce the most torque. The design for the inner supports of the wheel has yet to be selected. There are currently two options being considered: a "honeycombed' design in which holes of materiel are removed from a circular plate acting as a supporting structure, and a classic five spoke design.

The mining mechanism that VT Astrobotics will be implementing this competition cycle is also different from other design entries in the past. It has been dubbed the "Hybrid Shovel" and is inspired by a continuous mining machine. This reflects the expertise of the team members who are part of the mining and minerals engineering program here at Tech. The mining mechanism will consist of a drum, or cylinder, of fiberglass which will house a collection of scooping mechanisms. During preliminary design, the members of the Chassis, Bucket, and Mining Mechanism sub-team tested four scoop variations of the drum, namely flexible paddles, bristles, rigid paddles, and mini scoops. They found that while the rigid paddles collected the most regolith, they also generated a considerable amount of dust during operation. Conversely, the bristle option collected an amount of regolith comparable to the amount collected by the rigid paddle option, with starkly less dust produced during operation.


VT Astrobotics Team in Randolph 222 for design presentation.

Yet perhaps even above and beyond the design aspirations thus far mentioned, VT Astrobotics hopes to bring one more edge to the May competition that has never been attempted at a NASA Robotic Mining Competition: the team aims for its rover to complete the given challenge fully autonomously. This is one of the largest tasks being undertaken by the Programming, Power, and Autonomy sub-team (it's in the name, after all.) Should this task be accomplished, there is a large amount of points and prize money to be won from this area of the competition alone. Moving towards competition readiness, the Wheels and Drive sub-team will have the inner wheel support design selected and the wheels fabricated by late March or early April. Be on the lookout for these guys and gals; you'll know it's them if you see a group engineers testing their new rover wheels on last year's chassis on a volleyball pit in one of the quads. During spring break, the Programming, Power, and Autonomy sub-team will be working collaboratively on one big detailed flowchart for the loop processes that will control the rover. They will also be obtaining and testing necessary sensors as well as setting up the Xbox controller, which will serve as plan B should full autonomy not be achieved. The Chassis, Bucket, and Mining Mechanism will be finalizing material selection for their components subsequent to constructing the mechanism itself. To learn more about the exciting details of what VT Astrobotics is up to, visit:
https://www.facebook.com/pages/Virginia-Tech-Astrobotics/262263943845647

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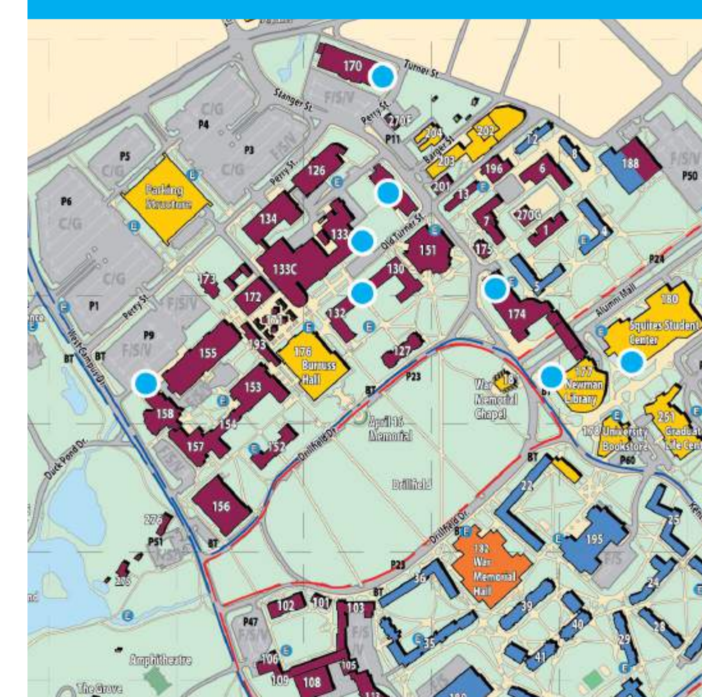

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