Solutions

INSIGHT • INNOVATION • IMPACT®

VANDERBILT SCHOOL OF ENGINEERING
Nashville, Tennessee

JUNE 2021

REACHING PICOSECOND
Optical computing

MAKING GRAPHENE
Membranes at scale

PROVIDING TOP-TIER
Training for ERDC

This issue of Solutions is dedicated to the Class of 2021. Your undergraduate experience ended in an unexpected and unprecedented way. Your resilience carried you across the finish line to join the global community of alumni, of which you will always be a part. Congratulations from the faculty, staff and alumni of the School of Engineering.

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A plan to transform a roof at Peabody College of Education and Human Development into a sensory oasis combines color, scent, texture and teaching. The design is one project by the Engineers Without Borders student organization.

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Corey Thomas, CEO of Rapid7, wants to hire people who are comfortable with being uncomfortable, people who are comfortable with messy.

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Matthew Walker III designed an innovative undergraduate design curriculum that leveraged connections across the engineering and medical schools as well as the biotechnology community. Walker, professor of the practice of biomedical engineering, died April 24, 2021, at his home.

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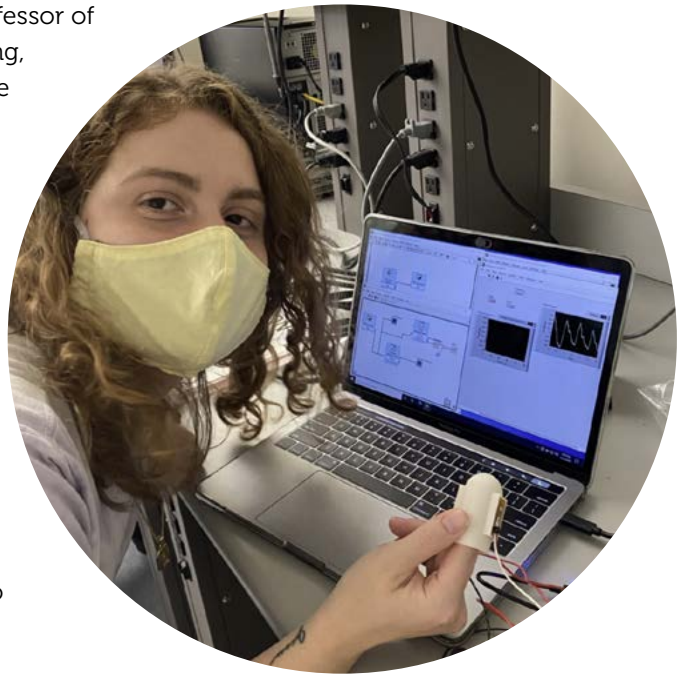
Designing classes for the COVID era

The move to virtual classes over the past year tapped into the creativity of engineering professors as well as students. Leon Bellan, associate professor of mechanical engineering, had students construct musical instruments from household objects. Virtual lectures on string resonance, pipe resonance and other acoustics phenomena then tied basic physics to musical instruments. Next, students tuned the instruments and predicted their pitch based on physics.

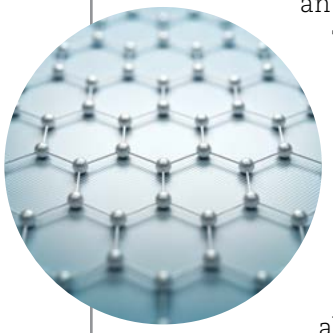
Romina Del Bosque, assistant professor of the practice of biomedical engineering, created a new instrumentation course and its lab, which was mostly taught remotely. She made kits for each student containing electronic components and instruments so they could get independent, hands-on experience.



Bellan and Del Bosque are among five faculty who received new awards for innovative teaching. Dan Arena, associate professor of the practice of computer science; Tyler Derr, assistant professor of computer science; and Kevin Galloway, research assistant professor of mechanical engineering, also received awards.

Scaling production of graphene membranes

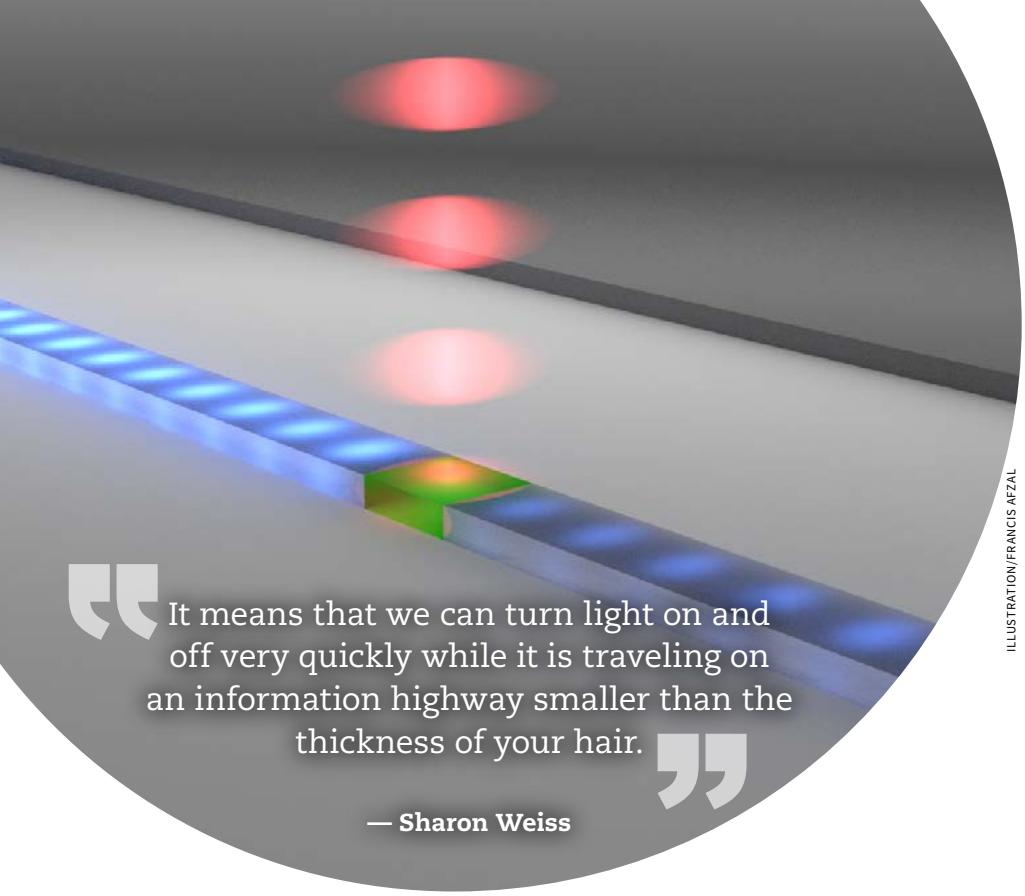
Graphene is a marvelous material, but can it be manufactured?



Vanderbilt engineers have demonstrated how, by combining a drop of rubbing alcohol, an office laminator and ingenuity. The hot lamination process enables a clean transfer of graphene to polycarbonate supports with 99.2 percent coverage—while preserving porosity.

The work is an important step toward making atomically thin graphene membranes scalable and practical for manufacturing, said Piran R. Kidambi, assistant professor of chemical and biomolecular engineering. The experiment produced membranes that outperformed state-of-the-art commercial dialysis membranes.

Graphene membranes present potential for breakthrough advances in separation of a variety of microscopic ions and molecules, including salts, proteins or nanoparticles, and are relevant to industrial applications for water desalination and gas separations. Such membranes also are useful for chemical, biological and medical research and the purification of substances used in pharmaceuticals.



ILLUSTRATION/FRANCIS AFZAL

Computing faster than one-trillionth of a second

A Vanderbilt team is the first to demonstrate that it may be possible to achieve data transmission rates exceeding one terabit per second on a single channel.

"It means that we can turn light on and off very quickly while it is traveling on an information highway smaller than the thickness of your hair that is made of the same material inside computers and cellphones," said Sharon Weiss, Cornelius Vanderbilt Chair and professor of electrical engineering, physics, and materials science and engineering.

The technology unjams bottlenecks in data streams using a hybrid silicon-vanadium dioxide waveguide that can turn light on and off in less than a picosecond, or one trillionth of a second. When another light pulse struck the vanadium dioxide, injected light pulses selectively turned off. The material properties of vanadium dioxide and the time duration in which the two laser pulses interact in the vanadium dioxide make possible the remarkable speed with which the light pulses were turned off and then came back on.

"We can turn light on and off faster than anyone else using this information highway, which means that future computers may be able to run a lot faster, and also with less power than current computers, by using light," said longtime collaborator Richard Haglund, Stevenson Professor of Physics.

Optimizing the size, shape and volume of the vanadium dioxide component and investigating alternate waveguide configurations are the next steps, researchers said.

Heart attack treatment in development to speed healing

Researchers have shown that early inhibition of a protein receptor in specialized heart cells speeds healing after a heart attack. The discovery has significant implications for survival, with a promising drug under development.

The team, led by David Merryman, a professor of biomedical engineering who holds the Walters Family Chair, found blocking serotonin 2B after a heart attack results in a functional scar that is less likely to expand beyond the initial wound to put additional pressure on the heart.

Typically, only a small region of the heart dies during a heart attack, but over time the borders of the scarred region expand. The resulting stress on the heart to do more with less induces heart failure. The researchers set out to precisely determine what the protein receptor did during heart attacks and how it might be altered for improved outcomes.

In collaboration with the Warren Center for Neuroscience Drug Discovery, Merryman is developing a highly targeted molecule that impacts only serotonin 2B in the cardiopulmonary system where the receptor is highly prevalent.

"This molecule has the possibility to not only treat myocardial infarction, but also high blood pressure in the lungs known as pulmonary arterial hypertension," Merryman said. "We are working with many clinicians to sort out the best path for drug development that we think has significant implications for human health."

student projects

Pandemic or not, engineers solve problems. Student engineers are no different, and undergraduate engineering students tackled a range of design challenges throughout the academic year.

Senior design teams, student organizations and interdisciplinary internships provided unique opportunities to learn by doing.

648 shipping containers + 11 acres + creativity = transformation

A team of civil and mechanical engineering students has a new vision for land Vanderbilt owns in a Nashville neighborhood—apartments for graduate students, restaurants and offices made from 648 used shipping containers.

The senior design project, sponsored by Nashville's Civic Design Center, is theoretical, but the team tackled it using real-world engineering skills, including load calculations, foundation materials, energy needs, transportation, sustainability and site evaluation.

With 89 apartments and four common areas, 60 percent of the building square footage is dedicated to residential living in the final plan. Restaurant/retail and research/office use account for 20 percent each.

Retaining some older trees, adding a path and aligning the structures to create open space contribute to a park-like atmosphere. The design includes 350 parking spaces, enough solar panels to generate at least half of the expected electricity load, and a 3,600 square foot area for covered, vented composting.

The range, volume and complexity of the decisions added to the challenge–and the fun. Students said they enjoyed the open-ended nature of the design process.

"There wasn't a single correct answer, said Chloe Namias, BE '21, who majored in civil engineering. "It was an extremely creative process, and it was all in our own hands."

Adding to Army medics' arsenal

Historically, an Army medic carries only one pelvic binder at a time, though IED attacks often injure multiple soldiers at once. A team of senior biomedical engineering majors devised a way around the limitations of medic pack size with a field-expedient pelvic splint.

The team created and tested a pelvic binder made from materials common to all Army medic packs, combining a combat application tourniquet and a SAM split. The latter, which consists of a thin layer of soft aluminum strips and a foam coating, is designed to immobilize bone and soft tissue injuries in emergency settings.

Doing research that could benefit medics and injured soldiers was a big part of the project's appeal, said team member Michael Jindia BE '21.

"We also really enjoyed the collaborative aspect of the project," he said. "The work was a combined effort of the four of us, our two VUMC/military sponsors, multiple staff engineers at Vanderbilt, and Dr. Matthew Walker III."

Walker, who developed the biomedical engineering undergraduate design program, died suddenly on April 24, less than a week before Design Day 2021.

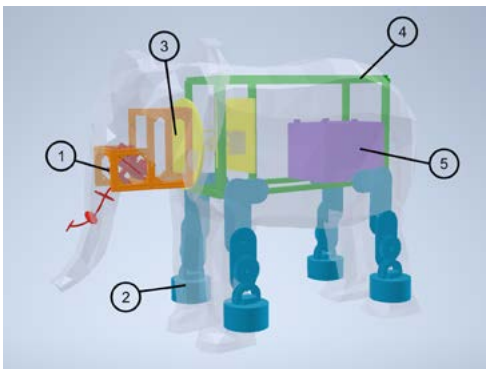
Pelvic binders or splints help stabilize a fracture in the field and reduce internal blood loss before transportation to a hospital for surgery. IEDs accounted for nearly half the deaths of U.S. soldiers in the last decade, most from internal arterial hemorrhaging. The casualties number in the thousands.

Building a baby elephant

That trunk is tricky.

It is true for a 200-pound newborn African elephant. And it is true for a team of engineering undergraduates tasked with building a full-scale prototype of a battery-powered elephant calf.

In nature, a baby elephant stands up seconds after birth but doesn't know what to do with its trunk for six months or more, swinging it around and at times stepping on it. In the lab, the trick is getting the subsystems to work together.



"The biggest technical challenges were balancing realistic trunk motions with complexity, supporting the weight of the head while moving the neck, and controlling and powering each system," said Stephanie Schroth, BE '21, who majored in mechanical engineering.

The team of three mechanical engineering majors and one in electrical engineering had broken the project into four subsystems—trunk, head and neck, legs, electronics—and controls. The students did succeed in getting independent motion of each system. "We were also able to assemble and wire them together into a battery powered elephant assembly," Schroth said.

The senior design project was sponsored by The Nashville Zoo, which asked the team to create an early version of a baby elephant for potential educational use in an exhibit of the African savanna. The idea is interaction with the toddler—who is 1 meter tall, 1.5 meters long, and 0.75 meters wide—would help people develop empathy for the animals as well as encourage preservation efforts.

student projects

Mitigating risk of wildfires

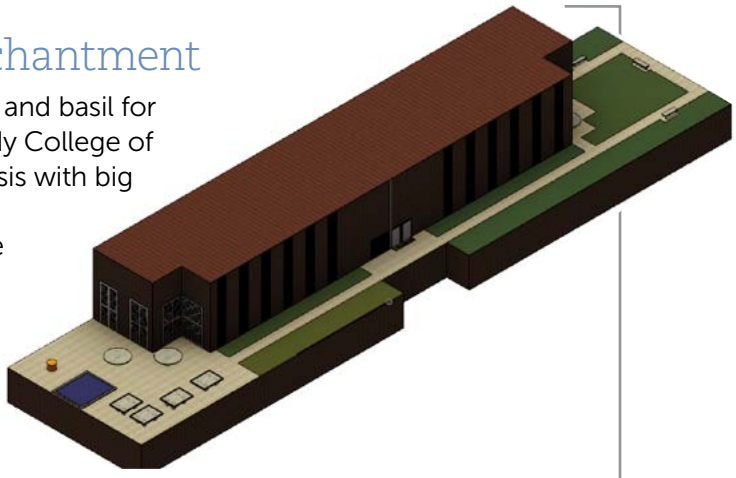
Residents of the Moraga-Orinda Fire Protection District northeast of San Francisco have access to another line of defense against approaching wildfires in an app that allows the district chief to remotely trigger their yard's sprinkler systems.

James Raubenheimer, BS '21, MS '21, built the initial prototype after entrepreneur Hubert Ma, BE '99, reached out and connected him with Chief Dave Winnacker for a project to use IoT-connected sprinkler hubs to mitigate the risk of wildfires. The fire district, in southwest Contra Costa County, has significant portions designated as very high fire risk severity areas.

Raubenheimer is a 2021 graduate with a bachelor's degree in computer science and mathematics and a master's degree in computer science. As a freshman, he founded Change++, a student organization that provides free development services to nonprofits. He built a quick prototype on the Rachio 3 Smart Sprinkler Controller, and he and the Change++ team improved upon it and recently demonstrated proof of concept with test users.

"Through some relatively basic fire modeling, we can tell where embers are most likely to be falling and those are the areas of the community we would cycle these sprinklers on," Winnacker said in an interview that aired recently on San Francisco's KNTV. He wants to expand access to other fire chiefs across California and is asking for help. What they need, Winnacker said, "is a large tech partner who can do this at scale so we can take advantage of the existing irrigation systems that are already present in the community."

A green roof for education and enchantment



Sedum for color, fuzzy lamb's ear for texture, and mint and basil for scent help anchor a plan to transform a roof at Peabody College of Education and Human Development into a sensory oasis with big environmental benefits.

A team of engineering undergraduates designed the green roof at One Magnolia Circle, which is home to the Susan Gray School, as part of the EPA RainWorks Challenge. The students are members of Vanderbilt Engineers Without Borders.

The Susan Gray School is an inclusive preschool where typically developing children learn alongside children with disabilities, and the outdoor space was designed with its students in mind. Plans include wind chimes, trellises from upcycled bicycle tires, and planting trays. The area as designed is ADA compliant, with tactile warning tiles for changes in elevation.

"Our roof is designed so that teachers and educators can bring their students, in groups of 12-15, to explore the garden, relax, and learn about plants and the environment," said Nicholas Lowe, a rising junior in chemical engineering.

With sedum as the primary plant, the green roof would cut runoff nearly in half, lower heating and cooling costs, counter the heat island effect and reduce noise pollution and $C0_2$ levels in the area. The estimated cost, which includes repairs and new railings, is $200,000. Implementation is under consideration by Campus Building and Construction.

Student-developed tech enables surgical tracking

TingYan "Nicholas" Deng, a rising senior, has used machine-learning algorithms similar to those that control autonomous vehicles to develop technology that analyzes surgical video from a camera worn around a surgeon's neck. It is the first known demonstration of open surgical wound detection using first-person video footage.

"Video is the ultimate objective record of what happens in the operating room," said Alexander Langerman, associate professor of otolaryngology. "If a patient needs a second procedure, the surgeon can see exactly what happened during the first surgery. Thinking even bigger, surgical video can identify ways to improve surgeon performance and the elements that affect patient outcomes. We just need to make sure we're capturing the right things."

Langerman and Cornelius Vanderbilt Professor of Engineering Benoit Dawant, professor of electrical engineering and computer science and director of the Vanderbilt Institute for Surgery and Engineering, worked with Deng. The project was developed during Deng's 2020 fellowship with Data Science Institute and also supported by VISE.

Deng, a computer science, math and economics major, said DSI workshops gave him a more concrete understanding of machine learning, lessons he applied to learn other algorithmic formations.

"The coolest part of this project is its interdisciplinary nature," said Deng, who interested in pursuing a data science graduate degree. "I was very excited to participate."

How to ...

...build a tiny home

Sean Ticknor, BE '99, founded Big Skills Tiny Homes to teach high school graduates the construction trades by building a tiny home. Each May, he recruits high school seniors in Marin County, California, who are interested in learning how to build. "Everybody is looking for good workers, but there is no clear path from high school into the skilled trades," said Ticknor.

After completing the nine-month program, students receive a $3,000 scholarship and Ticknor's help securing a job. He sold his first team's home for $50,000 to fund the next year's project.

Ticknor, a civil engineering major, worked as an engineer and structural designer for 18 years and has some tips for potential tiny home builders or buyers. First, decide whether to build on a foundation or trailer. Check land use and zoning regulations for the site. Make every inch count, but plan for the absolute musts—electrical, water and sewer connections; a small countertop, stove, refrigerator and sink in the kitchen; a toilet, shower and sink in the bathroom; and a bed—before committing to more. Design in as much storage as possible. Never skimp on ventilation for the kitchen and bathroom.

A simpler option is to buy one. "You can just order one and have it delivered to right where you want it," he said.

PHOTOS COURTESY OF BIG SKILLS TINY HOMES

...be a hydroponic farmer

HydroHouse Farms in Mount Juliet, Tennessee, supplies leafy greens to many restaurants and businesses in Nashville—including Vanderbilt Campus Dining. Before launching the hydroponic venture, owner **Hassan Sharaff, BE '07**, researched planting mediums, nutrients, environment, and water. He studied the nutrient film technique hydroponics system, which pumps a nutrient and water solution through grow trays. The rest was trial and error—adjusting temperature, humidity, water solution pH, and other inputs—and watching how plants responded. "Get some seeds, choose a medium and dive into it," he said.

Engineering undergraduates have helped Hassan troubleshoot, too. HydroHouse has partnered with "How to Make (Almost) Anything and Make it Matter," the immersion course taught by Research Assistant Professor of Mechanical Engineering Kevin Galloway, for two years. Using design thinking, student teams devise, test and modify solutions to answer a client need. One team created a more efficient cart to use while harvesting greens such as lettuce, arugula, basil and kale at night, fashioned from clear and white PVC parts and tricked out with remote-controlled LED lights.

Hassan, who majored in mechanical engineering, said his engineering background prepared him to work hands-on and to break problems into smaller components and attack them one by one "instead of feeling overwhelmed."

PHOTOS JOHN RUSSELL/VANDERBILT

...foster innovation

Together, siblings Charleson Bell and Charreau Bell have seven Vanderbilt engineering degrees and launched multiple companies.

Charleson, BE '07, MS '09, PhD '15, began his career as an entrepreneur while working on his Ph.D. in biomedical engineering and was the first Vanderbilt graduate student to receive venture capital funding for his startup. He is research assistant professor of biomedical engineering and National Science Foundation I-Corps consultant at the Wond'ry, Vanderbilt's Innovation Center.

Charreau, BE '09, MS '14, MS '16, PhD '18, is senior data scientist at the Data Science Institute. After she joined BioNanovations, her brother's venture, they and two other team members completed the I-Corps program. With a Department of Defense grant, the team is refining a way to deliver rapid blood tests at the point of care, using smartphone-compatible QR codes printed on paper.

The Bells emphasize that strong, inclusive networks foster innovation. "That's something I really love about the Wond'ry," Charleson said. "It's a place that brings people together from different backgrounds to share good ideas, and it's that inclusion of all perspectives and experiences that turns them into great ideas."

Charreau agrees. "It's critical to have inclusive networks and mentors of color," she said. "That's one of the reasons I think my role at the Data Science Institute is so important, and I am always eager to serve as a mentor to others."

7 Questions with Corey Thomas

President, CEO, Director of Rapid7

Infinite possibilities drew **Corey Thomas, BE '98**, to technology. Infinite curiosity fueled his interest, obsession even, with organizational behavior and the business side of technology. Rapid7, a cybersecurity tech firm based in Boston, has benefited from the combination of the two since 2008, when the founders hired Corey as SVP of marketing and sales. He moved up to COO and, in 2012, CEO, taking the company public in 2015. Previous positions include VP of marketing at Parallels Inc., a visualization technology company; group project manager at Microsoft, launching the worldwide availability of SQL Server and steering product planning for Microsoft's data platform; and a consultant at Deloitte Consulting. Corey, a member of the Vanderbilt Board of Trust, received a B.E. from Vanderbilt, majoring in electrical engineering and computer science, and an MBA from Harvard Business School. He reads five or six books at a time, a habit he cannot break, and commits to reading two works of fiction for every book of non-fiction. During the pandemic Corey took up archery and learned just how difficult a sport it is—more on that later.

1 Your early career was focused on figuring out "the recipe" for success. Where did that journey take you?

I always wanted to know the best practice for how to be successful in the world. From early on in my career, I assumed there was a single answer to that question and that I could figure it out by learning enough: If I do *these things*, I will know how to be successful and make it easy.

First, I thought it was organizational management and organizational behavior, which led to business school. Then in the first half of my career, I came up with different hypotheses and found career and learning opportunities to test them out: smart people, hard-working people, great strategy, great execution, great culture. But at some point, I learned that there isn't a definitive recipe and success is a process of discovery, not a state of knowing.

2 Thinking about your transition from middle to senior management, what was difficult about it? How did you know you were ready?

If you are confident that you are ready, you probably aren't. You need to have confidence in who you are and what you bring to the table, but temper that with humility and a deep appreciation of all the things you have to learn.

When Rapid7's founders hired me (first as an EVP, then COO), I had expected that if I did a good job, they would back me in my own venture. Rapid7 was founded by serial entrepreneurs, and I had wanted them to support me in starting a company of my own. I was shocked when I got the CEO opportunity, and I was a bit unprepared. I had to be convinced to take it, and I'm thrilled I did.

3 When it comes to workplace culture, you put a big emphasis on team building and interaction. How do you address the potential perils of "groupthink" against the potential contributions of an individual superstar?

Few geniuses can deliver consistently. It does not happen as frequently as you think, and there may be only two or three true geniuses in a generation. We are not the geniuses who are going to get it right across all times and all contexts, so context and the support of a team become incredibly important.

As Rapid7 scales out, we want people who have a high degree of self-confidence and humility. People who have high accountability, but a low need to control how exactly they deliver on that commitment with their team. If you think, "I was hired for my expertise in X," and you expect to come in and just do some X, you are not the right person for us.

4 How do your best hires demonstrate their intangibles?

I want people who are comfortable with messy. Really high quality, good decisions are not necessarily predictable. I tend to seek out unsolved problems and try to solve them, and I am looking for people who have insatiable curiosity. If you are debating an issue you are likely to be uncomfortable a huge percentage of the time. When we are engaging things that matter and don't know the outcomes, people are uncomfortable in the uncertainty. It should be a good experience, and nobody should be mean in the process, but there should be tension in not knowing and figuring it out. A great team pushes your assumptions about a problem and how to solve it.

5 You have said you expanded your definition of company culture to include how people, leaders, and the organization behave under stress. How does that play out in the line of fire?

I took Edgar Schein's model of organizational culture and, wanting to be very intentional, focused on behavior under stress. At those times, we should be explorers—collecting data, developing actions, responding, and making adjustments when something doesn't work. It is during these times of crisis and stress that a leader's personal behavior is most important because their behavior is scrutinized and adopted by their team—good or bad. Employees understand what is happening, and they want a culture that encourages them to help solve the problem.

That's why under stress we don't focus on certain aspects of accountability. When the dust settles, yes, talk about why it happened and how to prevent it in the future. But in the moment, you dig in. There's meaningful, psychological importance to employees seeing that their boss is willing to do the dirtiest jobs to support the team and find creative solutions under stress. We call it "Grabbing a shovel," and at Rapid7 we even have a rule that no one gets punished in the heart of the battle.

6 What gives you energy? What do you find relaxing?

What gives me energy is long walks, especially in nature. I describe myself as a, "Slow-burn introvert." I can engage with people for a long time. I do get creative energy from working through a problem by brainstorming and designing with two or three people. I am not very good at relaxing, though I do get some level of relaxation by learning new things. Over the years that has included guitar and martial arts, and during the pandemic I started teaching myself archery. I bought a cheap bow-and-arrow set and watched a lot of YouTube videos. The first time I hit the target—not even the bullseye, just hit the target—three times in a row, I wanted to have a party.

7 What would you tell one of your children who is a junior in college and stressing out about grades, internships, and social dynamics?

I would say, first, never forget that the goal is learning first and foremost and not validation. Validation may be good, but learning is the most important. Second, mistakes, struggles, and screw ups are not personal failings, they're part of becoming your best self if you learn from them.

ERDC partnership paves way for advanced Army Corps training

Thea Henslee is an Army civilian in the Corps of Engineers, a computer scientist, and a doctoral student in the School of Engineering.

She is the first service member to enter an engineering Ph.D. program within a partnership agreement between the U.S. Army Corps of Engineers' Research and Development Center and the Vanderbilt University School of Engineering. Corps employees take Vanderbilt engineering courses through the ERDC Graduate Institute course offerings.

"When I learned about the partnership between ERDC and Vanderbilt, it was a no-brainer for me. Vanderbilt gives me the chance to study machine learning in depth in a high-caliber program while also continuing to live and work in Mississippi," she said.

The partnership agreement, finalized in spring 2021, links top-tier experts from Vanderbilt and the U.S. Army Corps of Engineers for advanced workforce training. Of particular interest are graduate degree programs that include computer science, environmental engineering, risk, reliability, and resilience as well as non-degree workforce training programs.

ERDC's mission is to help solve the nation's most challenging problems in civil and military engineering, geospatial sciences, water resources, and environmental sciences for the Army, Department of Defense, civilian agencies, and the public good.

"Bringing these two institutions together to meet crucial societal challenges is mutually beneficial," said Bruce and Bridgitt Evans Dean Philippe Fauchet. "Research universities and the military working hand-in-hand can be transformative for our nation."

Henslee, for example, is on a team that specializes in data analytics and machine learning for the Computational Analysis Branch at the ERDC campus in Vicksburg, Mississippi.

"We work on a very wide range of USACE problems—anything from soil data to military construction to Operation Warp Speed (U.S. COVID vaccine response)," she said.

The range of tasks is one of Henslee's favorite things about working for the ERDC.

"We're always working on something new. The scenery is never the same," she said. "Working for ERDC is one of the best decisions I've made because it gives me the opportunity every day to serve my country, to solve very real problems, and to make an impact on so many lives."

> "Working for ERDC is one of the best decisions I've made because it gives me the opportunity every day to serve my country, to solve very real problems, and to make an impact on so many lives."
>
> **Thea Henslee, doctoral student in the School of Engineering**

Introduction to Design Day

On behalf of the School of Engineering, we would like to share the 47 engineering capstone design projects for 2021. We had capstone projects completed in partnership with sponsors including Nissan North America, NASA Marshall Space Flight Center, the Tampa Bay Rays, Sterling Ranch Colorado, Monroe Carell Jr. Children's Hospital, Nashville Civic Design Center, the Nashville Zoo, and many more. We thank all of our project sponsors, advisers, and mentors for their support of our design teams and the entire program.

Senior design courses provide students with experience working on real-world projects that involve design constraints, budgets, reviews, and deadlines. All the teams, sponsors, mentors, and everyone involved experienced a year that created a challenging environment for collaborative design. They will remember the adaptability and hard work needed to keep working from all corners of the globe.

Students learned about professionalism, teamwork, entrepreneurship, and, above all this year, resilience. As their projects take form, student teams interact with their industry and faculty advisers, hold meetings (perhaps more of them remotely), write formal documentation, and present their work. By the end of the academic year, the teams produce design processes, systems, prototypes, simulations, or virtual demonstrations.

This book is one of the tangible representations of Design Day, which has always been a celebration of all the lessons learned over four years of their engineering educations. As you read this book, know that those lessons were learned and demonstrated throughout all these projects.

We recognize the value of senior projects mentored and supported by external advisors—industry representatives, entrepreneurs, nonprofit mentors, as well as research and clinical faculty. This experience allows you to work with Vanderbilt engineering seniors and discover what makes our students stand out among other applicants when it comes to employment and postgraduate study. If you or your colleagues are interested in mentoring or sponsoring a project or to learn more, please contact me.

Be resilient, persevere, and work hard to make each other's world a little better each day. We are grateful for your support and guidance of our next generation of engineers and scientists.

With gratitude,

Thomas J. Withrow
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Vertical landing and orienting planetary imaging system

EECS-8
Trading and analysis derived from news and social data

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Match & Room

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ENGINEERING SCIENCE

FACULTY ADVISER
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ES-2
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ES-3
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ES-4
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ES-5
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ES-6
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ES-7
Mandatory Outpatient Treatment Tracking

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MECHANICAL ENGINEERING

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Sustainable redesign of DermaBlade

ME-2
Biofeedback training for MLB batting practice

ME-3
Design methodologies for additive manufacturing in space

ME-4
Nashville Zoo autonomous robotic elephant calf

ME-5
Nissan pick and place smart cart system

ME-6
Prototype handlebar and interface controls for a wheelchair

ME-7
Solar-powered soil moisture sensor network with real-time map

ME-8
System for stronger legs without exercise

ME-9
Autonomous manipulators for defusing underwater mines

ME-10
Vertical landing and orienting planetary imaging system

BIOMEDICAL ENGINEERING
BME-1

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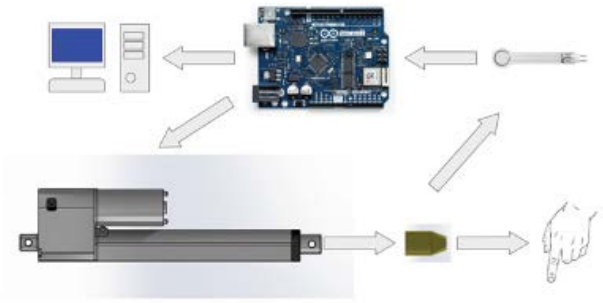
Computer-controlled device for pressure pain stimulation

Pain disorder researchers are interested in central sensitization, which can be triggered by repeated pressure on the top of the distal or intermediate phalange of a fibromyalgia patient's index finger. The tool of choice for pressure administration has been a hand-held algometer. Because a hand-held algometer is manually operated, it cannot apply the precise and replicable pressure sequences necessary for the research protocol. To address these needs, our team designed a computer-controlled device to perform customizable sequences of variable pressures and frequencies. The main components include a linear actuator as the pressure source, a stiff rubber tip for the point of contact, a force sensor to provide feedback, and an Arduino UNO microcontroller for processing and data storage. The electrical and mechanical components are enclosed by an opaque casing for a professional appearance. Our team hopes this device will be a valuable contribution to the study of fibromyalgia and the human nervous system.



Pressure is exerted by the actuator on the pressure sensor and the finger through a rubber tip. The pressure sensor provides information to the computer and feedback to the actuator through the Arduino.

VANDERBILT
School of Engineering

BIOMEDICAL ENGINEERING
BME-2

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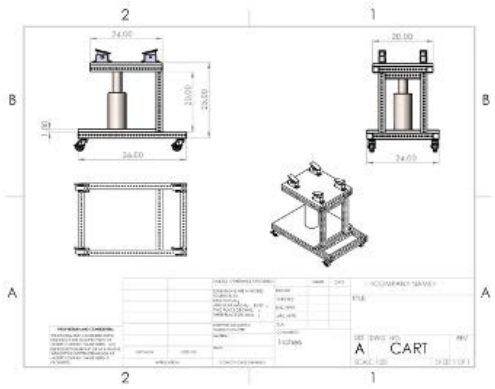
Monroe Carell Jr. Children's Hospital

Adjustable chair for video fluoroscopic studies

The Monroe Carell Jr. Children's Hospital performs swallow studies, which require children to be seated for up to 15 minutes. The current chair is uncomfortable and intimidating, making it difficult to for children to stay still. The chair does not suit children with certain disabilities, such as children in wheelchairs. Nor can the angle or height of the seat be changed. The result is subpar imaging. In addressing the chair's shortcomings, the team designed an updated chair that consists of a stand, a hydraulic lift, a 3D locking mechanism, and a booster seat. The booster seat locks onto the top of the stand. The new chair is adjustable in angle and height and gives hospital staff more flexibility when imaging children. The imaging plane is free of any metal or other radiopaque material that would interfere with the imaging process. The new chair design will allow hospital staff to perform swallow studies smoothly without the worry about the comfort and safety of the children.



The stand for the chair includes a hydraulic lift to adjust the angle of the seat, wheels for easy mobility, and attachment points for the seat.

Monroe Carell Jr.
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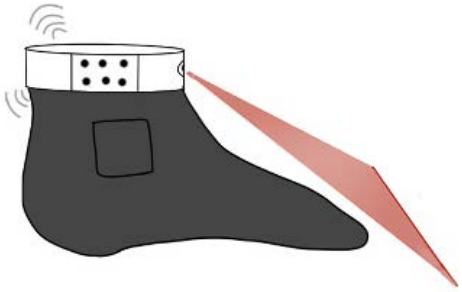
BIOMEDICAL ENGINEERING
BME-3

Wearable cue system to treat freezing of gait

Freezing of gait is a sudden, short, and temporary episode characterized by inability to move the feet forward despite intending to walk. FoG is a common and disabling condition, affecting 40 percent of Parkinson patients and increasing their risk of falls. We created a novel integrated wearable system to detect and treat FoG through visual, auditory, or somatosensory cueing methods. Our system first detects FoG through the Sensoria® sock, a smart sock that can collect data for real-time gait analysis. When the condition is detected, the system produces a vibration, auditory beat, or laser line signal to help patients overcome freezing. Patients can adjust the signal method to use one of the three cues or a combination of them. Few existing cueing systems incorporate real-time detection of FoG or user choice in signal types. We hope our solution provides Parkinson patients with a simple and comfortable way to relieve FoG symptoms and improve their quality of life.



The system includes a Sensoria® sock and a cueing device that outputs visual, vibratory, and auditory signals for treatment of freezing of gait.

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BIOMEDICAL ENGINEERING
BME-4

Wearable, multisensory medical alarm for ICU settings

Alarm fatigue, or diminished response to alarms due to desensitization, is a top health technology hazard. Current medical alarm systems are primarily auditory, producing loud, uninformative, and often clinically unimportant alarms. Continuous exposure to noisy and frequently false alarms contributes heavily to alarm fatigue in ICU nurses, which can lead to adverse patient outcomes. The project objective is to design a wearable, multisensory medical alarm system to reduce alarm fatigue and improve accuracy and alarm response in ICU nurses. An Apple Watch encodes information streams and transmits auditory, visual, and haptic stimuli for three vital signs: heart rate, oxygen saturation, and blood pressure. The device is personalized to the user's environment so nurses do not receive extraneous information, which will help reduce alarm exposure. Utilizing multiple stimuli to indicate different types of information will result in more informative alarms and reduce overall noise levels. This device aims to improve efficiency and ease of patient monitoring by ICU nurses, which will ultimately improve quality of care in critical care settings.

The visual interface of the Apple Watch application features two columns, representing two patients. Each row represents a different vital sign (top to bottom: heart rate, oxygen saturation, and blood pressure). Numbers represent current value, while colors indicate how the reading compares to normal: low, mid-low, normal, mid-high, or high. Arrows represent five-minute patient trends for each vital sign. Auditory and haptic alarms alert users to changes in vital state.

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BIOMEDICAL ENGINEERING
BME-5

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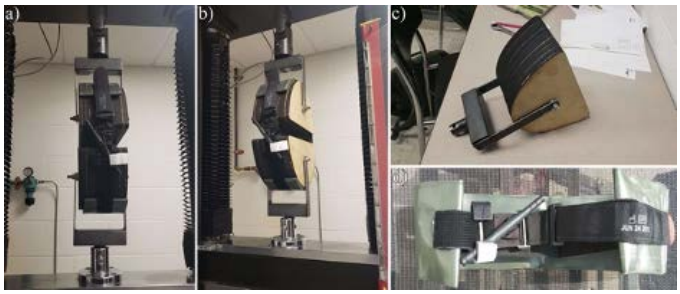
Field expedient pelvic splint for tactical casualty care

Pelvic ring fractures are a common military injury, affecting at least 4,800 U.S. soldiers in the last 10 years. These injuries, often caused by improvised explosive devices, are associated with a high mortality rate largely due to internal arterial hemorrhaging. Pelvic compression circumferential devices, more commonly called pelvic binders or splints, offer a means of treating pelvic fractures in the field, reducing internal blood loss prior to arrival at a hospital. However, due to limited space within medic packs, Army medics carry only one pelvic binder. IED events often affect more than one soldier. Our team has been creating and testing a pelvic binder that uses materials common to all Army packs and is designed to provide adequate compression of the pelvic ring. Our solution combines a combat application tourniquet and a SAM splint to create an improvised pelvic binder. We are performing mechanical tests on a pelvic model to determine if the binder can generate the benchmark force needed to non-invasively reduce open-book pelvic fractures.



Front view of the pelvic binder mechanical test apparatus (a), side view of the pelvic binder mechanical test apparatus (b), Mechanical tester attachment designed to mimic simplified pelvic anatomy (c), fully assembled field expedient pelvic splint (d)

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BIOMEDICAL ENGINEERING
BME-6

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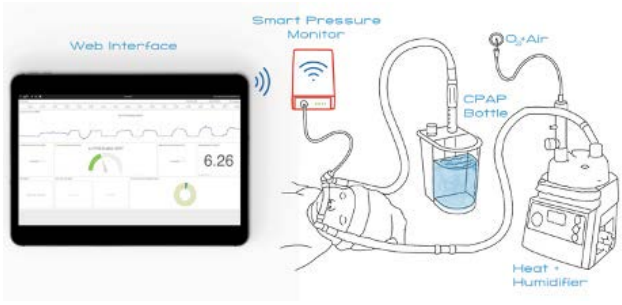
NICU bCPAP smart pressure monitor

The neonatal intensive care unit uses a ventilation technique known as bubble continuous positive airway pressure to treat premature infants who need respiratory support. VUMC's current technology only alerts nurses once the patient's blood oxygen saturation has dropped to dangerous levels. Research has shown that frequent hypoxia can cause permanent neurological damage and hinder long-term development. The smart pressure monitor addresses this problem by detecting pressure abnormalities prior to major drops in oxygen saturation. Pressure variation triggers a tiered alarm system based on a threshold value. A remotely displayed, gentle visual alarm is followed by audible signals if the pressure does not return to an acceptable level. The remote user interface also continuously displays patient data and stores pressure values for research purposes. Other bCPAP monitors are available, but our device provides the advantages of pressure logging and a tiered alert system paired with easy data visualization. It also addresses alarm fatigue—a desensitization that can lead to longer response times or missing important alarms.



The diagram depicts a preexisting bCPAP circuit with the added smart pressure monitor. The device continuously reads the pressure of the bCPAP system and will alert nurses to abnormalities. The web interface and patient data display is accessed through an iPad or other computer.

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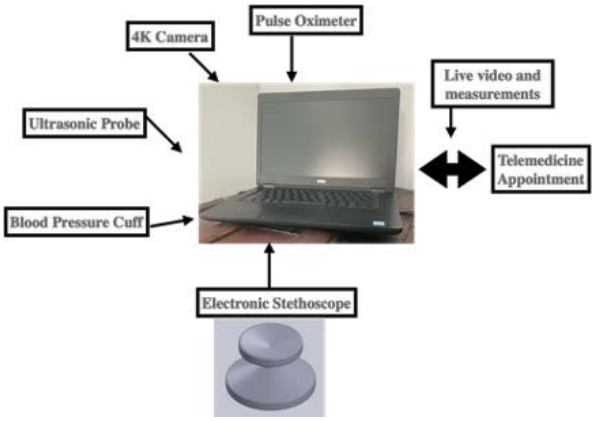
BIOMEDICAL ENGINEERING
BME-7

Remote stethoscope for telemedicine cardiology appointments

Cardiology patients at VUMC often travel many hours for a 15-minute appointment, and current telemedicine appointments are insufficient for true disease diagnosis and monitoring. We have designed an outpatient telemedicine device that will allow a cardiologist to make more accurate disease diagnosis in a remote setting. Rather than driving to Nashville, patients would visit a local clinic near their homes. During the video call with the cardiologist, a medical technician would use the device to replicate a typical physical exam. Key device components include an electronic stethoscope, ultrasonic probe, and 4K camera. The team has preliminary designs using a 3D-printed stethoscope head with an embedded microphone. Audio recordings of heart and lung sounds, in addition to other collected data, can be stored in the electronic patient records to monitor disease progression. Our device differs from other solutions because it is specialized for cardiology appointments. The completed telemedicine device is expected to replicate up to 80 percent of an in-person cardiology physical exam.



The telemedicine device includes an electronic stethoscope, ultrasonic probe, blood pressure cuff, 4K camera, and pulse oximeter.

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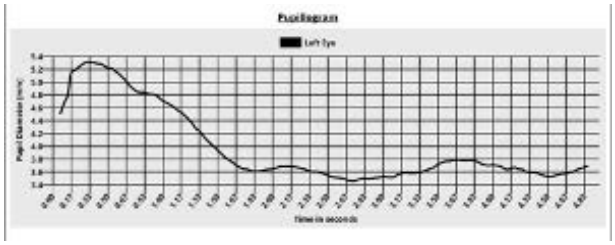
BIOMEDICAL ENGINEERING
BME-8

Non-invasive ICP measurement

When the brain experiences trauma, intracranial pressure rises within the skull, which can lead to seizure, stroke, or even death. Current methods of measuring ICP are invasive procedures during which various devices are inserted into the skull. High ICP correlates to a low pupillary constriction velocity, but existing market devices that measure it are very expensive. The goal of our project is to create a low-cost device that non-invasively measures ICP in a patient by using the pupillary light response. Our team incorporated Android app development for simplicity and camera functionality. The application utilizes OpenCV, an open-source computer vision library that applies filtering for locating and sizing the pupil. The team also is designing and 3D printing a casing similar to a VR headset to prevent interference from environmental stimuli. The anticipated result is an application that can take measurements of patients with moderate to high ICP diagnosis and output pupillary data, informing the physician of any potential danger.



The Android application uses OpenCV to locate and isolate the pupil, as seen in the box. The graph shows the results of analysis as the dilated pupil responds to a light stimulus and constricts.

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BIOMEDICAL ENGINEERING
BME-9

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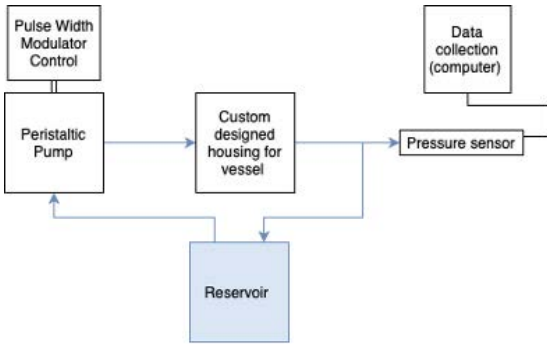
Bioreactor flow loop

Peripheral artery disease is a blockage of blood flow by atherosclerotic plaques. Balloons/stents are the standard of care to reopen the lumen and return blood flow to the artery. However, these treatments put stresses on the vascular wall that can cause a condition leading to additional blockages in 40 percent of patients. The project goal is to design an ex-vivo device to test concentrations of a peptide drug. The device must hold an artery and retain osmotic pressure while controlling flow rates and pressure. The drug would be delivered to vascular grafts to prevent hyperplasia. To investigate whether the vessel will retain the peptide, our device incubates the vessel for 1-2 hours while maintaining hematological conditions. The system, a bioreactor flow loop, is easy to fabricate, cost effective, and reusable. It supports ex-vivo optimization of pressure, treatment time, volume, and concentration prior to any clinical trial.



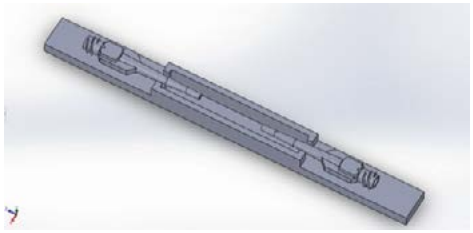


Figure 1. Bioreactor flow loop design schematic
Figure 2. Custom designed housing that can hold vasculature of varying sizes

BIOMEDICAL ENGINEERING
BME-10

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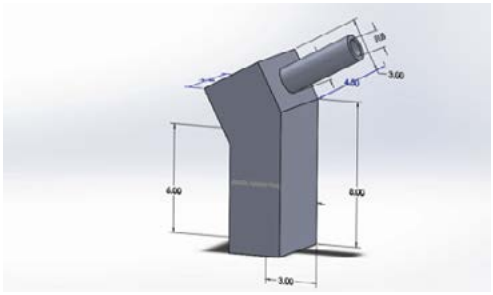
Breathalyzer to diagnose metabolic and infectious diseases

Two challenges in infectious disease diagnosis include test accuracy and speed. For example, rapid diagnostic tests for COVID-19 only detect a true positive test 34-to-80 percent of the time. More sensitive COVID-19 diagnostic tests, such as PCR/saliva tests, can take several days to analyze completely. One method to achieve reliable and rapid detection may incorporate patient breath samples. Various metabolic and infectious diseases are known to generate gaseous particles, called volatile organic compounds, that are expelled in the breath. Different diseases have different VOC signatures. The VOCs may be separated and analyzed based on geometry, size, or charge. For this project, we aimed to create a breathalyzer device that uses ion mobility spectrometry to determine a VOC signature. IMS is commonly used to separate gaseous ions based on their size and geometry, and it generates a real-time signal. Our breathalyzer device uses a library of such signals stored on a microcontroller to match the VOC signature in a patient's breath. The device allows quick and accurate diagnosis of the underlying pathology.



The breathalyzer stands 11 inches tall and weighs 3.31 pounds. It has a tube emanating from one of the upper faces through which users breathe. A screen on the front face displays the results.

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CHEMICAL AND BIOMOLECULAR ENGINEERING
ChBE-1

Design of a multi-product craft brewery

Craft beer has risen in popularity over the past decade, reaching 13.6 percent of the U.S. beer market by volume and $29.3 billion in sales in 2019. Our team has been tasked with designing a microbrewery that brews five recipes year-round and seven recipes seasonally. Target production levels are 10,000 barrels per year for each year-round recipe and 100,000 barrels for total annual production. Each type of beer has a set of requirements for the pH, IBU (international bitterness unit), % ABV (alcohol by volume), turbidity, and color. Our team must develop recipes, price raw materials, price and size equipment, develop a brewing schedule, and decide whether to build a new facility or contract our brewing to existing facilities. Also, our process must have an environmentally friendly, zero-emissions design. The goal is to determine the cost of in-house brewing compared to the cost of outsourcing production.

Brewing equipment used by craft breweries.

Polymer & Chemical Technologies, LLC

Chemical Engineering Design Advisory Board

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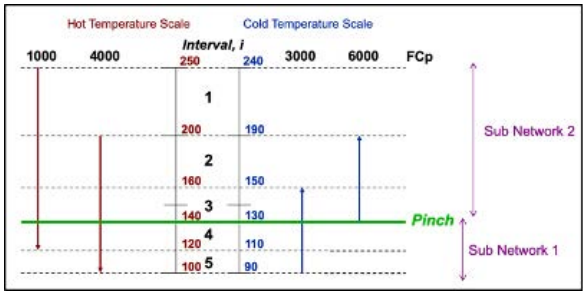
CHEMICAL AND BIOMOLECULAR ENGINEERING
ChBE-2

Software for automating chemical engineering tasks

Chemical plants are designed to minimize operating costs by optimizing interactions between process units, known as process integration. However, the wide variety and context-specific design constraints imposed by industrial problems make finding globally optimal process integration solutions a challenge. Our novel software, ALChemE: Assistive Libraries for Chemical Engineering, will identify financially optimal designs for heat and water integration networks given a set of relevant process streams and user-defined constraints. By contrast, existing software tools generally fail to converge on financially optimal solutions and/or fail to transform design constraints into appropriate mathematical analogs. ALChemE also will produce graphical representations based on pinch-point analysis, provide cost estimation data for the generated solutions, and enable direct manipulation of solution networks by the user. Finally, we have written ALChemE in a free and open-source programming language. We hope this will transform ALChemE from a process integration design tool to a full chemical plant design suite.



Our software automatically generates temperature interval diagrams, which can also show the properties of each stream.

Chemical Engineering Design Advisory Board

CHEMICAL AND BIOMOLECULAR ENGINEERING
ChBE-3

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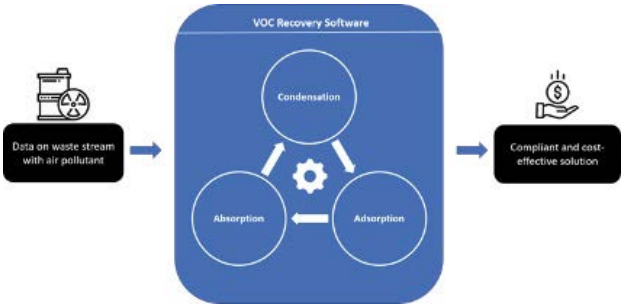
Modeling VOC recovery as cost-effective air pollution control

Chemical process industries must comply with federal EPA laws that govern emissions of air pollutants such as volatile organic compounds. Currently, most CPIs rely on destructive technologies like flares to combust excess VOCs and reach acceptable emission thresholds. Although effective, these technologies provide no avenue for cost-efficient waste recycling to upstream process stages, resulting in a strong, yet unrequited, opportunity cost for conservation. Our objective was to investigate and model alternatives to flares for facilitating conservation. We created a model that enables CPIs to perform comparative operational and economic analyses on absorption, adsorption, and condensation for VOC recovery. This model accepts inputs that include VOC fraction in a waste gas flow, desired VOC removal efficiency, and design parameters that provide outputs of quantity of recovered VOCs and cost effectiveness for each alternative. Our model could enable CPIs to analyze both the operational and financial efficiency from implementation of VOC recovery, informing stronger approaches to environmental and social governance.



Our VOC recovery software could support cost-effective approaches to air pollution control.

CHEMICAL AND BIOMOLECULAR ENGINEERING
ChBE-4

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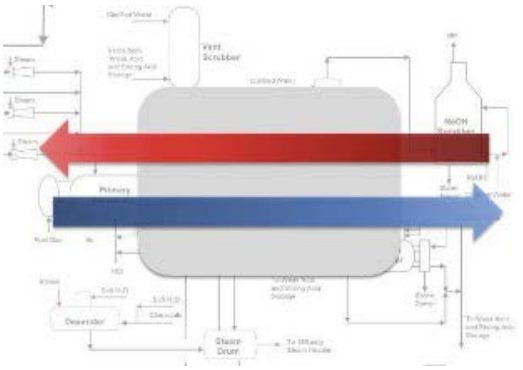
Heat exchanger network for a complex chemical plant

Chemical plants have high energy costs often due to the heating and cooling requirements of specific processes, with heating alone accounting for 30 percent of a plant's energy consumption. Plants burn fossil fuels to heat streams using pressurized steam and acquire water from local sources to cool streams, but this results in significant material and environmental costs. To reduce these costs, the team proposes using a heat exchanger network to transfer heat from streams that need cooling to streams that need heating in an ethylene dichloride synthesis and purification plant and an EDC cracking plant. For the design process, the team used software to identify potential stream pairs for which heat exchange can occur. With this data, our team is creating several potential designs, keeping in mind the economic benefits and potential hazards of each. The resulting design is expected to significantly reduce the use of steam and cooling water compared to the existing setup, which would reduce the operating costs of ethylene dichloride plants.



Heat exchanger networks from the EDC synthesis and purification plant and the EDC cracking plant integrate utilities, create energy savings, and reduce operating costs.

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CHEMICAL AND BIOMOLECULAR ENGINEERING

Mobile system for treating hydraulic fracturing wastewater

Companies use high pressure water to extract oil and natural gas through hydraulic fracturing. The process returns water to the surface as wastewater that has a high concentration of contaminants. Typical treatment involves deep well injection, a practice with detrimental effects on public health and the environment. Our goal is to treat this wastewater and use it in a more environmentally and economically conscious way. We designed a mobile wastewater treatment system for a hydraulic fracturing well that treats the wastewater for reuse in agriculture. The system consists of four process units, each removing a certain class of contaminants. A team of tractor trailers transports the equipment from well to well. Treating the water on site avoids excessive shipping costs, and we reclaim and sell the effluent rather than disposing of it. As designed, the system will treat up to 1 million gallons of water each month.

The mobile wastewater treatment plant, hauled on tractor trailer units, will include electrocoagulation, dissolved air flotation, ion exchange, and membrane distillation units.

Polymer & Chemical Technologies, LLC

Chemical Engineering Design Advisory Board

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CHEMICAL AND BIOMOLECULAR ENGINEERING
ChBE-6

Design of a cost-effective silane plant

Silane is a useful commodity chemical in the production of the specialty chemicals called polysilanes, a growing global market with ink-jet and screen-printing applications. An external supplier offered to sell electronic-grade silane as a starting material for $60/kg. The team aims to design an in-house production process of 50 metric tonnes per year of electronic grade silane at a lower cost than the external supplier quoted. The plant design for silane production must have previous industrial use, with demonstrated safe design, operation, and production capacity. The team designed a production method based on the Union Carbide Process that uses two reaction zones and three separation zones to produce electronic-grade purity silane. The design improves on previous designs by adding a second reactor to each reaction zone, which decreases the flow rates through the largest reactors by 25 percent. The team anticipates the production cost for 50 metric tonnes of electronic grade silane to be lower than the supplier's price of $60/kg.

The REC Silicon plant in Montana uses the Union Carbide Process, with alternating reactors and separators to manufacture silane, while using recycle streams to minimize waste.

Chemical Engineering Design Advisory Board

CHEMICAL AND BIOMOLECULAR ENGINEERING
ChBE-7

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Design of a sulfuric acid plant

The team designed a chemical plant that produces 500 tons of pure sulfuric acid per day using a cost-effective, environmentally friendly process. The main goals were to document the system for producing the daily output, ensure resulting emissions do not harm the environment, and conduct cost analysis to maximize profit. Initially, the team produced sulfuric acid by decomposing natural hydrated sulfate minerals and condensing the resulting gas. This process was time consuming and expensive, but it was the only way to make relatively pure sulfuric acid. The team implemented the contact process in their design. The team decided this was the most modern, efficient method for making sulfuric acid, though it is time consuming as well. Through detailed process analysis and calculation, the team developed an in-depth synthesis path and complete site plan for the plant. The goal is a safe and efficient plant that produces both 93.5 percent and 98.5 percent sulfuric acid while also minimizing cost.

General chemical process equipment in a typical sulfuric acid plant.

CHEMICAL AND BIOMOLECULAR ENGINEERING
ChBE-8

TEAM
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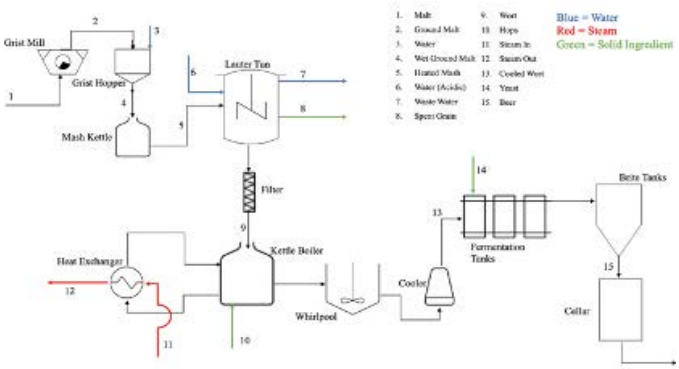
Professor Bryan Beyer, ChBE

SPONSOR
Polymer & Chemical Technologies, LLC,
Chemical Engineering Design Advisory Board

Design of a multi-product brewing process

The project's objective is to design an economically and environmentally conscious process to micro-brew seasonal and year-round varieties of beer. The team must evaluate the economic viability of two approaches: designing new facilities or using existing facilities to contract brew our products. We must account for any waste produced, and the goal is zero-emission production. The brewing process involves grinding grain into a mash and then activating it with heat and water. The mash is then separated and fermented into an alcoholic beverage. The expected result is a brewery that is economically and environmentally efficient and meets the team's needs and the needs of the surrounding community. A "no waste" brewery adheres to environmental regulations while retaining high profit margins.



The process flow diagram demonstrates the layout of the brewery with the equipment and general ingredients needed to make the different brews.

TEAM
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Daniel Shin, CE

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James Moore, landscape architect, Vanderbilt
Kurtis Eisenhuth, GIS analyst, Vanderbilt

SPONSOR
Vanderbilt University

CIVIL AND ENVIRONMENTAL ENGINEERING
CEE-1

Americans with Disabilities Act campus design

Many areas on the Vanderbilt campus can be difficult to find and navigate, especially for students, faculty, and visitors who need accessible routes. The ADA campus design project hopes to increase accessibility, enhance wayfinding, and provide easier methods of using sustainable transportation on campus. This project aims to identify trouble locations on campus, devise ADA-compliant solutions, develop a wayfinding app, and create plans for implementation. The only digital, GPS-supported navigation map for the campus is Google Maps, which routinely sends users on inaccessible pathways. Furthermore, existing physical maps spread throughout campus are outdated and dilapidated. The wayfinding app will directly solve this lack of proper navigational tools. Still, many areas of campus, including areas deemed "ADA accessible" remain inaccessible to many users. The team's redesigns will ensure that these trouble spots will meet all ADA requirements. The design project will increase accessibility on campus for all users, regardless of ability, by making more ADA compliant designs and developing a wayfinding app.

VANDERBILT UNIVERSITY

Team member Kailey Newcome measures the length of an ADA parallel parking space by the Owen Graduate School of Management to check for compliance issues.

TEAM
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Nick Ormsby, CE
Matthew Sato, CE/Math
Laurel Baldwin White, CE

ADVISERS
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Tyler Rosburg, P.E., ICON Engineering
Mark C. Hildahl, P.E., Wilson & Company, Inc.

SPONSORS
Sterling Ranch Development Company

CIVIL AND ENVIRONMENTAL ENGINEERING
CEE-2

Bridge and stream rehabilitation design at Sterling Ranch

Sterling Ranch is a new, master-planned community in Littleton, Colorado, that continues to expand onto previously undeveloped land. As the community grows, impermeable surfaces increase and cause greater flow through Willow Creek, which must be addressed and mitigated. To connect the new development to current roads, two identical bridges must be built over Willow Creek. The bridge design includes a load analysis of the proposed bridge and reinforced concrete design of the girders, deck, cross beam, piers, drilled shaft and pile foundation, wing wall, and approach slab. The stream stabilization design consists of a redesigned alignment, new typical cross-sections, and bed and bank reinforcement structures. In addition, an impact study of native and endangered species ensures construction follows Colorado regulations. Lastly, the creek design implements native riparian structures to mitigate flooding and erosion of the stream. Our partnership with the engineers of record on this project helped us create pragmatic design solutions that are provided in a set of CAD plans.

An aerial view of Sterling Ranch shows existing stream conditions and the proposed bridge design.

STERLING RANCH COLORADO

CIVIL AND ENVIRONMENTAL ENGINEERING
CEE-3

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Steve Edwards, P.E., Barge Design Solutions
Kevin Smith, P.E., Barge Design Solutions

SPONSOR
Civic Design Center

Sustainable, multi-use shipping container development

As the cost of land continues to increase in the Nashville metropolitan area, site redevelopment is an alternative to greenfield development. The project's aims to develop plans for turning an underutilized, 11.5-acre property in the Wedgewood-Houston area into a mixed-use site with a focus on sustainability. Elements of the proposed site include residential units for Vanderbilt graduate students, retail shops, restaurants and cafes, and office space for the university. The project encompasses site layout, construction management, and structural design, plus modular construction requirements, energy systems, and mechanical systems design. Shipping containers were selected over typical building methods for the environmental, economic, and social benefits of living small and reusing old containers. The development utilizes a modular, prefabricated construction plan to reduce costs, improve quality, and expedite construction. To ensure sustainable methods, the development also meets three petals of the Living Community Challenge: Energy, Water, and Materials. The work can be used to demonstrate the feasibility of a large shipping container development in Nashville.

3D model of a residential unit built using six 40-foot shipping containers with bedrooms, bathrooms, kitchen, dining, and living space

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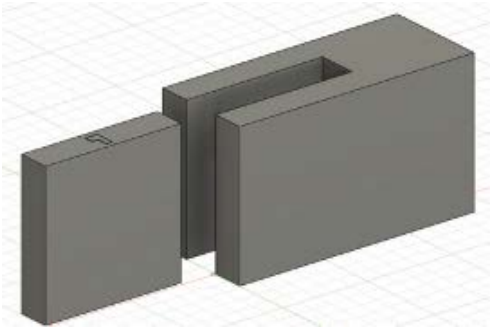
SPONSOR
Vanderbilt University Medical Center

ELECTRICAL ENGINEERING AND COMPUTER SCIENCE
EECS-1

Tracking hospital patients with an RFID intravenous catheter

The goal of the radio frequency identification-enabled intravenous catheter is to provide a secure, reliable patient tracking tool that will allow health care workers to locate patients. Because they move or are moved, patients can be difficult to locate, especially during emergencies and check-ins. This project integrates a passive RFID tag with an intravenous catheter, which will be tracked by RF readers set up around the hospital. Location data will be saved to a database, and a user interface will allow medical personnel to search for a patient's location. The system excels over past patient-tracking methods such as wristbands and badges because it is firmly attached to an IV. Wherever a patient goes, the RFID-enabled catheter goes. It also saves the time of medical staff, who provide care to several patients during one shift, by providing quick patient location without the need to consult colleagues. The system can be easily integrated into VUMC operations.



The device casing is comprised of two parts: a hollow enclosure for an RFID tag and a solid overlay that will connect to the hollow enclosure using an epoxy adhesive.

VANDERBILT UNIVERSITY MEDICAL CENTER

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SPONSOR
Department of Music and Cognition, VUMC

ELECTRICAL ENGINEERING AND COMPUTER SCIENCE
EECS-2

Turning cognitive tasks into games

The Music Cognition Lab administers a series of tasks to test the linguistic abilities of children. The current methods involve giving these tasks on paper and relying on spoken instructions with dull illustrations to manually test the children's capabilities. The lab has tasked the team to develop video games to administer these tests in a more engaging way for children and increase the accuracy of the linguistic data. The theme of the game is an adventurer searching for treasure, traversing a jungle and castle. The main gameplay element is a background narrator telling the user to pick a character or object for a specified purpose. Once the player makes a choice, a timestamp is recorded. At the end of the game the data is exported as an Excel file. This solution improves upon other methods because it provides an element of interactivity that is fun and exciting to most kids. Our team anticipates this will increase children's engagement and produce better results for the Music Cognition Lab.

The game, programmed in Unity, has interactable objects, a player character, and audio prompts to signal the player when to act.

VANDERBILT UNIVERSITY MEDICAL CENTER

ELECTRICAL ENGINEERING AND COMPUTER SCIENCE
EECS-3

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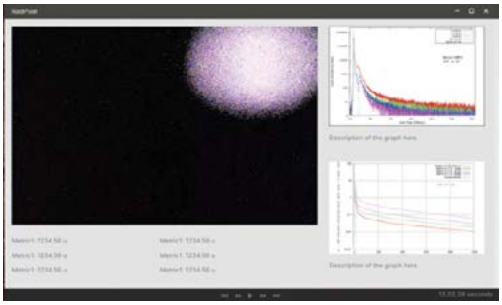
SPONSOR
Vanderbilt Institute for Space and Defense Electronics

Characterization of an imager under irradiation

Vanderbilt's Institute for Space and Defense Electronics is interested in studying the effects of space and radiation on electronic components such as commercial imagers. In particular, the lab sponsoring this project has specific interest in the following data sets: alpha particle button source, pulsed X-ray, laser, and ARACOR. The team has worked to design, develop, and test a desktop application for analyzing the real-time and post-process characteristic effects on imagers under irradiation. The application will read in-video input, pre-process the data to ensure consistency, and output analytical information based on the video data. This software solution will allow the lab to decrease the time needed to analyze radiation effects of the video data collected as image processing algorithms will handle the bulk of the analysis. Other users interested in analyzing the effects of radiation and noise detection in their imager data may also find this solution helpful.



Mockup of desktop application with imager video playing and real-time data and graphs populating the screen

ELECTRICAL ENGINEERING AND COMPUTER SCIENCE
EECS-4

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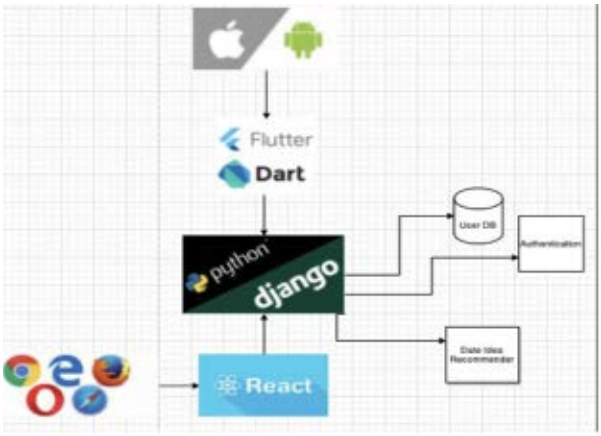
SPONSOR
Twinsun Solutions

Generating uniquely random dating ideas

Datr aims to solve the problems of analysis paralysis and decision fatigue. The application will generate random dating ideas for users based on their location, inputs to a questionnaire about dating, and other social activities. Their experiences suggested by Datr also will be factored in. Users will access the app through their mobile device or any modern web browser to receive tailored dating ideas. The system consists of iOS and Android applications along with a web client. The components will communicate with a common backend server to ensure information is transferred seamlessly as users move from their phones to their laptops. The application aims to connect users and the people they are close with by providing them with accessible and exciting activities based on their preferences.



The Datr application consists of a web client, a mobile client, and a backend server that communicates with both. The backend server utilizes the Django Python framework and manages user authentication, data storage, and dating idea recommendations. The mobile and web applications are written utilizing Flutter/Dart and React, respectively.

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Joseph Polt, Universal Lighting Technologies

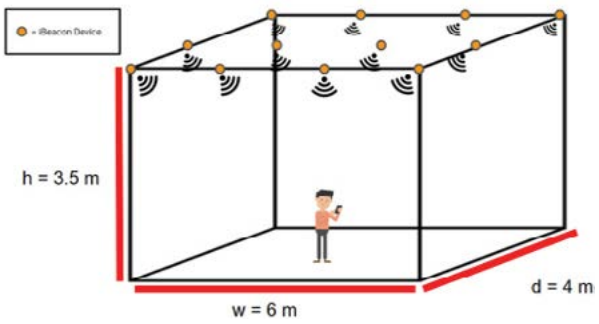
SPONSOR
Universal Lighting Technologies

ELECTRICAL ENGINEERING AND COMPUTER SCIENCE

EECS-5

ULT—indoor positioning system—Phase II

Many industries have increasing interest in an indoor positioning system. A working IPS would be helpful in large indoor spaces such as warehouses, airports, retail stores, hospitals, and more. The goal of this project is to pinpoint a user's position to within 2 meters of their actual location. The main hardware components will include Bluetooth low-energy beacons installed in ceiling light fixtures and an Android phone. The system will use the relative signal strength intensity from a beacon array and combine this input with the input generated by the internal sensors on the phone, called pedestrian dead reckoning, to generate the most accurate positioning estimate. An Android-centered IPS is preferred over other systems that have been created because it relies on a phone, which most people carry with them. No additional hardware is needed.



Our indoor positioning system uses BLE beacons installed in the ceiling to communicate with the Android device. Combining this input with the input from internal sensors on the phone allows the system to achieve the most accurate positioning capability.

Universal Lighting Technologies

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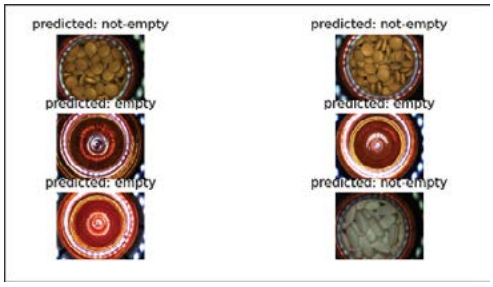
SPONSOR
Quality Manufacturing Systems, Inc.

ELECTRICAL ENGINEERING AND COMPUTER SCIENCE

EECS-6

Empty vial detection

Automated mail-order pharmacies, which fill thousands of prescriptions each day, still must check all prescription vials before they are shipped to customers. This project's goal is to develop a real-time method of determining whether prescription bottles on an assembly line have been filled with pills. The design must be highly accurate and speedy to meet the demands of an automated pharmacy operation. The team chose to use a convolutional neural network due to its potential for quick and accurate image classification. The network was trained and tested using hundreds of images of prescription vials taken with the same type of industrial camera and high-power ring lights used by automated mail-order pharmacies. The OpenCV software library was used to take images from the camera and run them on the trained neural network, which classifies each image as "empty" or "non-empty." These results can be logged in real-time, providing pharmacy managers data to track performance.



Results from a convolutional neural network trained to distinguish between empty vials and vials with pills inside. This model was trained as a binary classifier using transfer learning.

QMSI

ELECTRICAL ENGINEERING AND COMPUTER SCIENCE
EECS-7

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SPONSOR
NASA

Vertical landing and orienting planetary imaging system

Planetary exploration involves safe infiltration in adverse and unknown conditions, visual assessment of the surrounding environment, and data transmission to the home base. The payload team of Vanderbilt Aerospace Design Lab aims to meet these requirements with a quadrupedal payload that will land vertically, autonomously reorient within 5 degrees of the vertical, take a 360-degree panoramic image of its surroundings, and send it to the base station. The team is designing a mechanically intelligent, passive leg deployment system, parachute detachment system, and an active leg actuation system. The image capture and data transmission will take place through a PiCam and an XBee communication module, respectively. The onboard Raspberry Pi 4B computer will perform the necessary computation. The team validated the design and functionality of the leg deployment and parachute detachment systems through drop tests from varying heights and landing conditions. The payload's structural integrity was tested through finite element analysis and validated from drop tests and a subscale flight of the rocket. The next steps are to debug the leg actuation system to achieve leveling and integrate some form of mobility to the payload.

The team assembling the full-scale rocket at the launch field

ELECTRICAL ENGINEERING AND COMPUTER SCIENCE
EECS-8

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Asaf Roth, CS/Applied Math

ADVISER
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SPONSOR
Vanderbilt School of Engineering

Trading and analysis derived from news and social data

The price of stocks and cryptocurrencies highly correlates with social media and traditional news media coverage. Existing research has shown that single social media feeds can predict the price of cryptocurrencies. This project tries to answer the question whether a trading strategy can be derived from those inputs, using a holistic framework for analysis and creation of automated trades. The first version of this project collects information from news and social feeds and allows users to subscribe to see what, if any, assets are trending on different websites. The second version will allow users to analyze the sentiment of online information against the various data points of a given asset. The third version of this project allows the user to create an automated trading strategy based on the news and social media feeds. The anticipated result is a positive return on a given investment that utilizes the automated analysis of social and news feeds.

The live news feed of stock data from Reddit, Twitter, and other news providers.

VANDERBILT
School of Engineering

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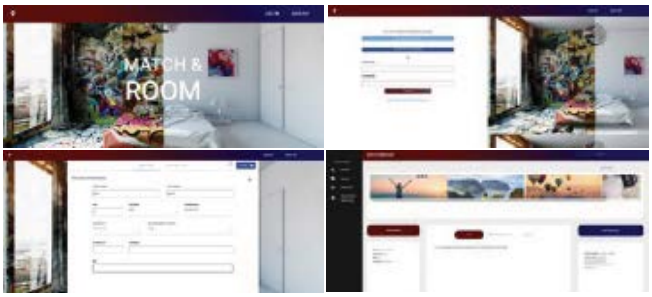
SPONSOR
Vanderbilt School of Engineering

ELECTRICAL ENGINEERING AND COMPUTER SCIENCE

EECS-9

Match & Room

Without a popular website that identifies potential roommates, people typically use Facebook Groups and Craigslist, both relatively static platforms with limited search and sort parameters. Match & Room is designed to fill this need and allow people to find their ideal roommate through a dynamic and interactive interface. This website will feature a user friendly and modern front-end, a machine learning algorithm that presents the best potential matches to each user, and in-app chat functionality. Potential roommate matches will be presented to the user one-by-one, and the user can select "no" to move on, or "yes" to keep the candidate for consideration. The team plans to gather data and conduct user testing to train the machine learning model. Match & Room improves on existing solutions, which are not as dynamic and only present potential roommates in a list form. The new service aims to not only provide a fun, more interactive way for people to find roommates but also contain a well-trained machine learning model that only offers users the most ideal candidates.



The screenshots of the website prototype include the home, login, registration, and profile pages.

VANDERBILT
School of Engineering

ENGINEERING SCIENCE
ES-1

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Jennifer Schad, Development and Alumni Relations

SPONSORS
Division of General Engineering
Vanderbilt School of Engineering

Engineering Management alumni initiative

The Engineering Management minor (formerly known as the Management of Technology minor) within the School of Engineering exposes engineering students to business concepts and theories they can apply in their careers. Due to the versatility of the program, alumni have pursued varied career paths. The project goal was to reconnect and engage with graduates of the program. The team developed and deployed a survey to 1,700 program alumni to understand the impact of the EngM minor on their careers. Analysis of the survey results sheds light on alumni demographics and perspectives on the EngM minor. An additional project component was the planning and execution of alumni networking events for current and prospective EngM students. Continuation of this project will involve an alumni advisory board and future program initiatives.

The project aims to understand the impact of the Engineering Management minor on the career paths of 1,700 program alumni.

VANDERBILT
School of Engineering

ENGINEERING SCIENCE
ES-2

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Professor Courtney Johnson, General Engineering

SPONSOR
Marc Sebes, creator of HUGS parent communication hub

HUGS: Parent communication hub

Parents today receive several forms of communication from their child's school. These communications involve separate channels for various parts of the child's academic life as well as their extracurricular activities. With busy lives of their own, many parents find it challenging to keep track of important updates, deadlines, and progress reports. HUGS provides a platform that takes communication from the school and presents it in an integrated and easy-to-read format for parents. The main elements of the project include a calendar that accumulates and categorizes information. Additionally, the platform is being designed to provide notifications, updates, and deadlines. The app creates a single source of information so parents no longer will need to manually sort through emails and messages. The goals are to decrease the time parents spend planning schedules, simplify updates on their child's progress, and reduce the possibility of missed deadlines and important events.

This word map visually represents keywords parents mentioned during interviews. The size of each word corresponds to its frequency of use.

HUGS

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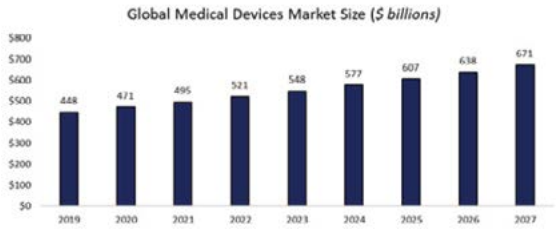
Professor Courtney Johnson, General Engineering

SPONSOR
NeXTMed LLC

ENGINEERING SCIENCE

Smart pill bottle startup market research

Poor medication adherence in U.S. and international healthcare systems translates into billions of dollars in costs and suboptimal health outcomes. Rising healthcare costs and fragmented relationships between physicians, pharmacists, and insurers have created the need for simpler and cost-effective products to ensure medication adherence. The smart pill bottle is an innovative product that retains the form of a physical pill bottle but integrates technology to monitor and encourage adherence. The team created a report detailing the target market and financial strategy for NeXTMed. The report highlights major competitors, market sizing, legal frameworks, and financial projections that aim to create a seamless transition from product design to product sales. The team anticipates the report will provide viable and effective strategies to take advantage of the industry's nascency and bring the product to market.



The global medical devices market is expected to grow at an annual compounded rate of 5.2 percent, reaching $671 billion by 2027.

NeXTMed

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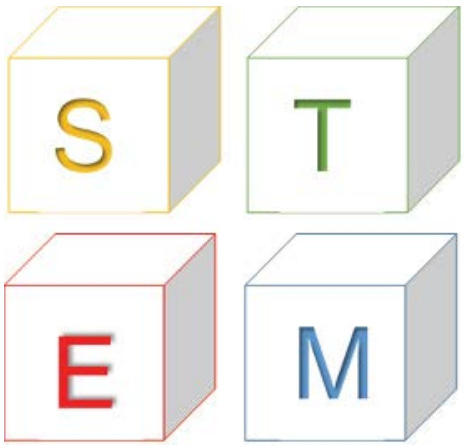
SPONSORS
Division of General Engineering
Vanderbilt School of Engineering

ENGINEERING SCIENCE
ES-4

Marketing plan and strategy for STEM educational product

The STEM educational toy market is one of the fastest-growing aspects of the toy industry. Over the next two years, the market is expected to grow 23 percent annually. Our team partnered with an entrepreneur who has designed an innovative STEM product for children. While the sponsor focuses on product development, the team has served as consultants to support the sponsor's vision. The project is to develop a technology marketing and innovation strategy plan to introduce the product to potential investors and bring it to market. The team is compiling a market and competitive analysis along with a quantifiable revenue build. Based on the research and analysis, the team is providing recommendations and guidance to the entrepreneur on how to navigate the STEM educational toy landscape.



STEM toys provide an entertaining way for children to learn about science, technology, engineering, and mathematics.

VANDERBILT
School of Engineering

ENGINEERING SCIENCE
ES-5

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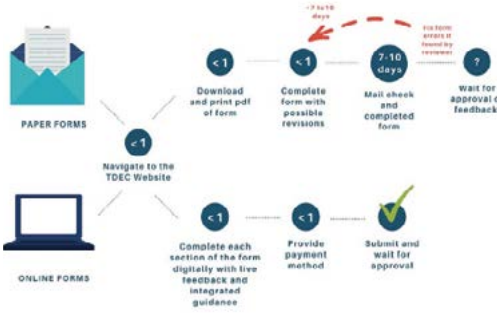
Professor Courtney Johnson, General Engineering

SPONSOR
TEDC Division of Water Resources

MyTDEC Forms

The MyTDEC Forms project addresses how the Tennessee Department of Environment and Conservation, Division of Water Resources, accepts forms and permit applications. The goal is to partner with the agency in creating and modifying an online form system to replace its paper-based process. Within the existing online platform, the team is building intuitive and interactive forms that guide users through each section of the application. With the new system, users can complete their "paperwork" with ease and efficiency. Our project also allows the team to create an FAQ database for the TDEC HelpDesk, evaluate user experience, and provide training for applicants and permittees. The advantage of the online forms over the existing paper forms is greater efficiency and accessibility. The new system also allows for real-time results to be fixed, forms to be verified, and questions to be answered. Therefore, this new and improved system will help the agency streamline the form submission process.



TDEC is converting its process for submitting forms and permits to an online system for ease and efficiency.

TN Department of Environment & Conservation

ENGINEERING SCIENCE
ES-6

TEAM
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SPONSOR
TM TKO, LLC

Business entity and trademark data acquisition

TM TKO, LLC, offers an online tool that companies and individuals can use to research trademark and business entity information. The company provides solutions including trademark clearance, office action research, and watch services. Watch services monitor trademarks, which includes tracking applications, providing updates on competitor's activities, and surveillling legal actions pertaining to trademark law. All 50 states store trademark and business entity information separately and in varying formats, making it difficult for TM TKO to synthesize all this information. The project goal was to compile trademark and business entity information from all 50 states. Additionally, our team analyzed cost, data set format, update schedule, and contact information for each state. Based on our analysis and recommendations, TM TKO will decide whether to move forward with acquiring these data sets to serve as an additional resource for their customers.

Acquiring trademark and business entity data from each of the 50 states requires a state-by-state approach as each jurisdiction differs in record-keeping methods.

TM TKO

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Professor Courtney Johnson, General Engineering

SPONSOR

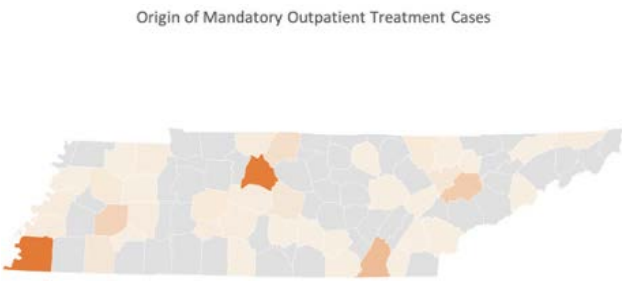
Tennessee Department of Mental Health & Substance Abuse Services

ENGINEERING SCIENCE

ES-7

Mandatory Outpatient Treatment Tracking

The Tennessee Department of Mental Health and Substance Abuse Services requires improvements to the tracking capabilities of its Mandatory Outpatient Treatment initiative. The spreadsheets used now for progress tracking provide suboptimal efficiency, inadequate patient data security, and difficult maintenance. A software upgrade could remedy these deficiencies, benefiting both the agency and the patient population. This project involves identifying a suitable software platform that meets the requirements established by the sponsor and developing an implementation plan that outlines the actions for successful adoption. Our team intends to research potential software solutions so we can confidently recommend the platform that offers the best chance of supporting meaningful improvement in tracking patient progress. Further, we will consider what is needed for successful implementation and possible obstacles to that goal, generating a plan that effectively facilitates the transition to the proposed software platform.



This heat map displays the distribution of active mandatory outpatient treatment cases in Tennessee (FY2020), colored by county. The two highest concentrations of patients reside in Shelby County (199) and Davidson County (45).

TN Department of Mental Health & Substance Abuse Services

MECHANICAL ENGINEERING
ME-1

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SPONSOR
Vanderbilt University Medical Center

Sustainable redesign of DermaBlade

The DermaBlade, individually packaged and disposable, is the most commonly used shave biopsy and shave excision instrument in academic dermatology centers. The tool consists of a thin blade bonded to a flexible plastic handle, making it ideal for a wide range of procedures. Unfortunately, it also creates unnecessary waste as the entire tool is placed in a medical sharps waste container after a single patient use. The team redesigned the product so the blade can be separated from the handle prior to disposal, allowing each handle to be redirected to an alternate waste method. With reverse engineering, CAD software, and 3D printing technology, the team created and refined mechanisms for DermaBlade 2.0. Combined with packaging created from second-use plastics, DermaBlade 2.0 is a more environmentally sustainable product that provides the same safety, flexibility, precision, and ease of use that make the original DermaBlade such an effective tool.

The DermaBlade redesign features a pivot point that allows the user to bend the device and release the blade, making the system more environmentally sustainable and retaining the same safety, flexibility, and precision.

VANDERBILT UNIVERSITY MEDICAL CENTER

MECHANICAL ENGINEERING
ME-2

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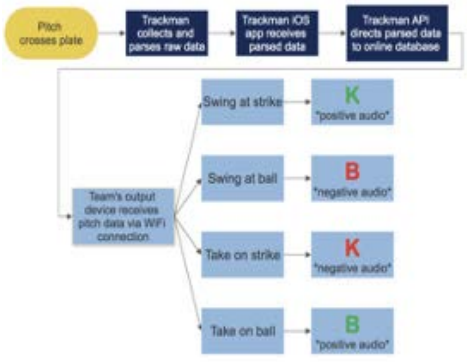
Tampa Bay Rays

Biofeedback training for MLB batting practice

During batting practice sessions, no reward system encourages hitters to focus on plate discipline. Motivations during practice can conflict with incentives during games, leading to ineffective practices and bad habits. At games, it is less rewarding to take pitches outside the strike zone. With no consequences at practice, however, players swing at every pitch. To address this gap, the team engineered a device that provides visual and audio feedback based on pitch location and batter response. Situated behind the pitcher's L-screen, the device contains an LED screen that displays a "K" or a "B" if the pitch is a strike or a ball, respectively. The device also houses a Bluetooth speaker, which detaches for placement closer to the batter, and the system provides simultaneous feedback based on the swing decision. A portable Trackman unit, a high-tech camera system the project sponsor uses, exports pitch location data via an API to the Trackman. The overall design offers simple, yet effective feedback during batting sessions, aligning hitters' motivation in practice with the plate discipline required during games.



The system output gives customized visual and audio feedback to hitters based on pitch location and batter response.

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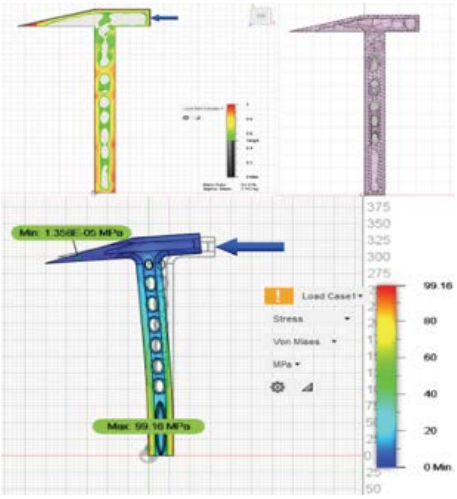
SPONSOR
NASA Marshall Space Flight Center

MECHANICAL ENGINEERING
ME-3

Design methodologies for additive manufacturing in space

To reduce cargo space and mass, NASA intends to develop 3D printing technology for low gravity applications and redesign of parts and tools for in-space additive manufacturing. Minimizing the material usage required to print each part is a priority. Additionally, designs must avoid the inclusion of support material to minimize waste and debris. To achieve these goals, the team used generative design and topology optimization software to inform the redesign process.
After creating a design methodology, the team tested the methodology by redesigning a geology toolkit based on designs from previous Apollo missions. The redesigned toolkit includes a rock hammer, scoop, rake, tongs, and a universal handle capable of connecting to all of these tools. In future missions, crews will be able to 3D-print these tools in aerospace-grade titanium and use them for geological studies on lunar and Martian surfaces.



A test case for the project design methodology uses a simplified rock hammer. Starting with a stress analysis [A], topology optimization software showed where material could be reduced without sacrificing part strength [B]. A manual redesign of the handle reduced part mass by 30 percent [C].

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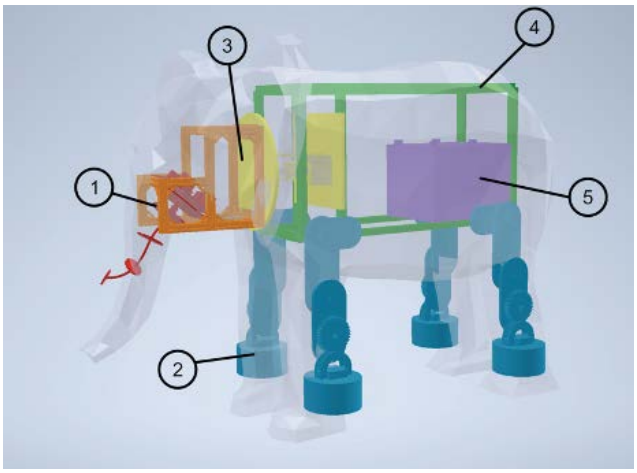
SPONSOR
Nashville Zoo

MECHANICAL ENGINEERING
ME-4

Nashville Zoo autonomous robotic elephant calf

Elephants are an integral part of Africa's ecosystem, but they are vulnerable to climate change, loss of habitat space, and poaching. African elephants are classified as a vulnerable population, with about 415,000 of them in the wild. The Nashville Zoo wants to build a 40-acre African exhibit to encourage participation in conservation efforts. This project aims to develop an animatronic elephant calf robot with which the zoo patrons can interact and develop empathy for these animals. The team is building a full-scale prototype approximately 1 meter tall, 1.5 meters long, and 0.75 meters wide. It is broken down into controls plus four subsystems: trunk, head and neck, legs, and electronics. Each subsystem will provide realistic motions, including walking, head, and trunk movements, all powered by an internal battery.



A model of the animatronic elephant calf robot with integrated subsystems: [1] trunk, [2] legs, [3] head and neck, [4] body, and [5] batteries and electrical components

MECHANICAL ENGINEERING
ME-5

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SPONSOR
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Nissan pick and place smart cart system

At the Nissan North America manufacturing facility in Smyrna, Tennessee, workers use carts to transport parts from the warehouse to the manufacturing assembly line. The carts differ in size and configuration. For assembly, all parts must be arranged on a cart in a specific order, and workers load parts based on the labeled bin numbers. However, workers may mistakenly load parts into incorrect bins, causing delays. The project's objective is to design a prototype that reduces loading errors and decreases operational delays. The team designed a light indication system to direct workers who load parts. LED lights are placed around each bin to clearly signal the correct bin for a specific part. To ensure compatibility with all carts regardless of their configuration, the lights are fastened to adjustable columns. These columns allow a reconfigurable design based on the cart model. This design will reduce loading errors thereby increasing loading efficiency.

The CAD model (left) has three columns of lights and is used with carts that have two columns of bins. The prototype (right) is shown in front of an existing cart model. The green lights direct users filling the bins where to load the next parts.

MECHANICAL ENGINEERING
ME-6

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SPONSOR
Permobil

Prototype handlebar and interface controls for a wheelchair

The project aims to improve a manual add-on system for an existing wheelchair model to serve a greater number of users. The current front attachment design allows wheelchair users to convert the chair from a manual to a motorized device that assists them in traveling up hills or covering varied terrain, all while lessening the physical toll of propelling a wheelchair. The current design, however, is geared toward manual wheelchair users who have the hand dexterity and strength to operate a twist-throttle and squeeze-brake lever, much like those found on a standard bicycle handlebar. Users who are quadriplegic, stroke victims, or have other special needs may not be able to operate such a control design. Our objective was to design, prototype, and test a quadriplegic-friendly throttle and brake controller that modularly interfaces with a typical handlebar. For proof of concept, the team designed and built a push-brake mechanism and a thumb-tab throttle. All components were additively manufactured to work with the current wheelchair model. The enhancements should expand use of the wheelchair to those with limited ability to grip, squeeze, and twist.

Prototype for handlebar and new control interface on a BATEC electric front-attachment, with wheelchair and user

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SPONSOR
Root Nashville

MECHANICAL ENGINEERING
ME-7

Solar-powered soil moisture sensor network

Root Nashville wants to plant and maintain 500,000 trees in Davidson County by 2050. The design project's goal is to address Root Nashville's greatest need by engineering a scalable and affordable soil moisture sensor network to optimize tree maintenance. Additionally, an integrated map interface will present the real-time data on the moisture content of tree sites. The design solution features wirelessly integrated components that consist of sensors, solar-panels, rechargeable Li-ion batteries, and Wi-Fi and LoRa-enabled microcontrollers. The sensor systems will routinely wake on a schedule, collect data, transmit the data wirelessly to an online database, and return to a low-power sleep mode. A real-time map interface automatically retrieves information from the online database and updates the dashboard for tree sites. This solution improves upon Root Nashville's current process, which does not use a centralized, digital method of tracking watering needs. The device will provide Root Nashville with more accurate data and save time and resources spent checking weather patterns and watering trees that have sufficient water.

Sensors wake intermittently to collect soil moisture data and transmit data via a LoRa transmitter and receiver network. LoRa receivers are Wi-Fi integrated and automatically update an online database with real-time information. Integrated solar panels harvest energy and charge Li-ion batteries to passively power sensor devices.

root nashville

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SPONSOR
Vanderbilt University Advanced Robotics and Control Lab

MECHANICAL ENGINEERING
ME-8

System for stronger legs without exercise

The Vanderbilt Advanced Robotics and Control Lab tasked our team to assist with their "stronger legs" project. The stronger legs exoskeleton system is designed to assist warehouse workers with lifting heavy objects while remaining flexible in most orientations. The warehousing market has more than 1 million workers, many of whom lift heavy objects each day. Our design pairs the lab's proprietary sliding node technology with a locking spring mechanism designed by the team. The sliding node design allows for changing the effective stiffness of the spring when compressed and locked, releasing stored energy as upward force with passive power input. The locking spring mechanism, which must be able to lock at any point, delivers a high force while requiring minimal force to lock and unlock. The final design combines a coil spring for most of the force and a lockable gas spring in parallel. This innovative solution provides a powerless design that is not available in similar exoskeleton models.

The lockable spring system is attached to the exoskeleton with pin connections at each end.

VANDERBILT
School of Engineering

MECHANICAL ENGINEERING
ME-9

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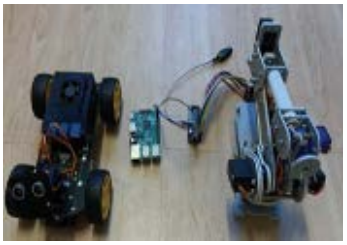
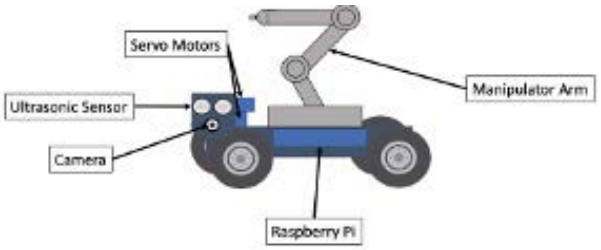
SPONSOR
Naval Surface Warfare Center - Panama City Division

Autonomous manipulators for defusing underwater mines

Underwater mines pose a major threat to maritime operations by blocking shipping routes, restricting naval movement, and endangering nautical transportation. Because current defusal methods risk human life, more advanced defusal techniques are needed. Recent prototypes of autonomous underwater vehicles have generated interest because of their safety and smaller sizes. This project aims to create a robotic system capable of autonomously performing the functional tasks associated with the process of defusing a mine. Under current constraints, the team designed a land-based parallel device with identification software and a manipulator arm that would unscrew a screw or bolt found on a mine. The process has four main components in order of operation: object recognition, screw/bolt identification and image processing, manipulator control, and end effector deployment. The system will successfully locate and identify a screw at a specific point in space and unscrew it with the manipulator arm.



The distance detector locates the desired object, and the camera identifies and sends coordinates to the manipulator arm, which then performs the unscrewing task. The system also includes two Raspberry Pi 4 8GB microcomputers. One handles sensors and the car movement. The other handles the manipulator arm.



MECHANICAL ENGINEERING
ME-10

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SPONSOR
NASA

Vertical landing and orienting planetary imaging system

The Vanderbilt Aerospace Design Laboratory designs, builds, tests, and demonstrates a launch vehicle and payload system for the annual NASA University Student Launch Initiative competition. The objective is to fly a rocket to an apogee between 3,500-5,500 feet, then, during descent, jettison a lander capable of leveling itself within 5 degrees of the vertical. Once level, the lander must capture and transmit a 360-degree panoramic photo. The nose cone of the launch vehicle doubles as a component of the lander body and will be ejected axially from the rocket during the jettison event with the descent slowed by its own parachute. The lander consists of four legs, each actuated by a motor to ensure proper levelling for capture of the panorama photo. The team continuously refers to predefined NASA and mission requirements to assess the success of the overall project.

Vanderbilt Aerospace Design Laboratory's rocket and planetary lander payload for the 2020-2021 NASA Student Launch Initiative competition

Design and project faculty

We take great pride in recognizing these faculty members who are the core of our design program. Their outstanding contributions and excellence as instructors, advisers and mentors in our senior design and project courses have led to the work demonstrated on Design Day 2021 and have transformed our Class of 2021 into young professionals.

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Lecturer in Chemical and Biomolecular Engineering

JASON MITCHELL
Research Assistant Professor of Mechanical Engineering

RALPH BRUCE
Professor of the Practice of Electrical Engineering

LORI TROXEL
Professor of the Practice of Civil and Environmental Engineering

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THOMAS WITHROW
Assistant Dean for Design
Associate Professor of the Practice of Mechanical Engineering

COURTNEY JOHNSON
Assistant Professor of the Practice of Technical Communications

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Vanderbilt University School of Engineering
- Advanced Robotics and Control Laboratory
- Advanced Therapeutics Laboratory

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2021 Senior Design Winners

THOMAS G. ARNOLD PRIZES

The Thomas G. Arnold Prizes for Biomedical Engineering Systems Design and Research are shared by **Stephanie Lauren Nolan**, Apopka, Florida, for research; and, for design, by **Alexander Douglas Boyd,** Paris, Tennessee; **Jake Robinson Emrich**, Evergreen, Colorado; **Courtney Morgan Klapka**, Forest Hill, Maryland; and **Jolie Alyse Lerner**, Chappaqua, New York, for the project: NICU bPCAP smart pressure monitor.

C.F. CHEN BEST DESIGN AWARD

The C. F. Chen Best Design Award for the best design in the Department of Electrical Engineering and Computer Science is shared by **John Galloway**, Charlotte, North Carolina; **Jason Chuangqi Lao**, Irvine, California; **Yoni Xiong**, Albuquerque, New Mexico; and **Rodman Yuxi Zhu**, Cary, North Carolina; for the project: Empty Vial Detector.

MECHANICAL ENGINEERING DESIGN AWARD

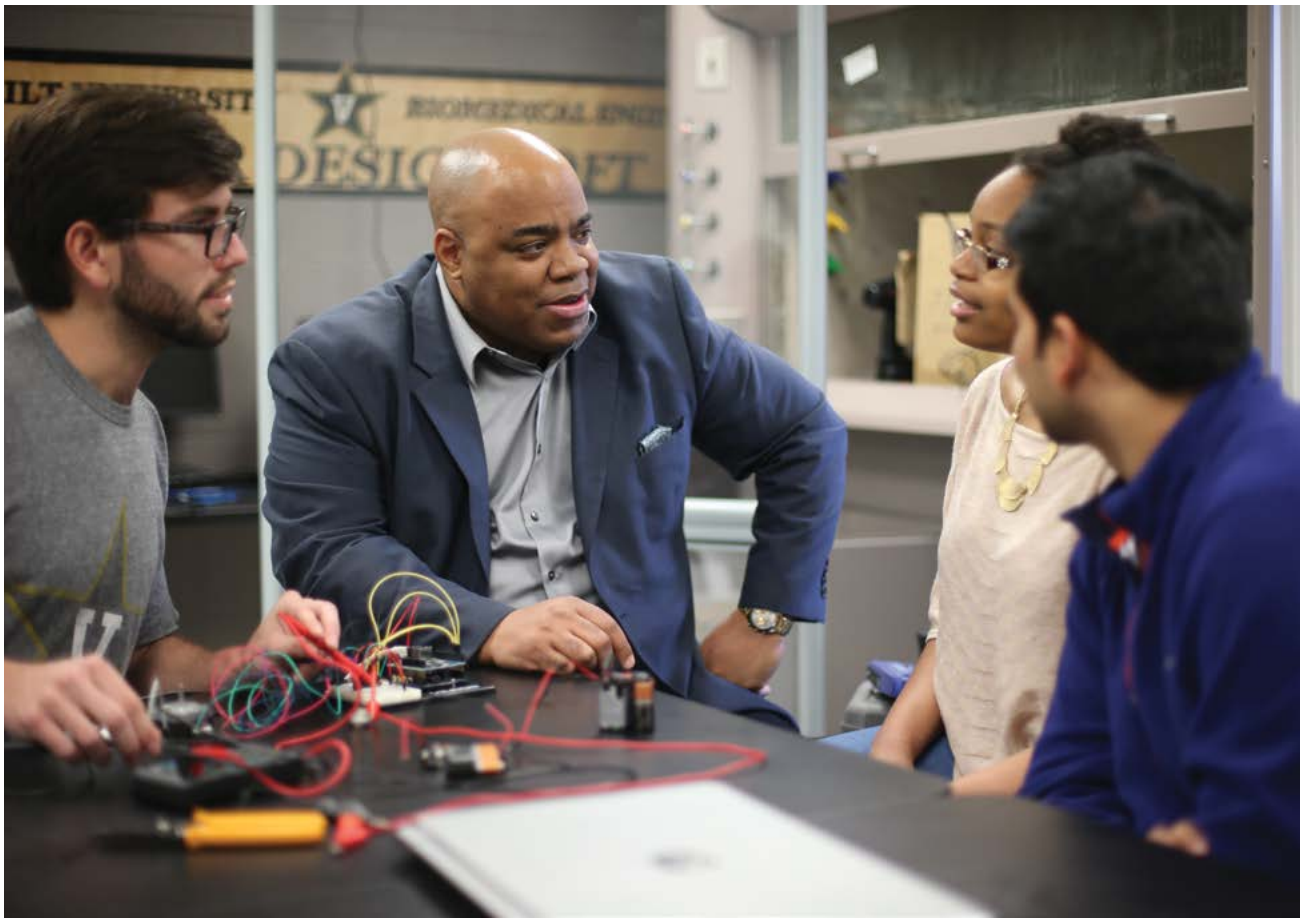
The Department of Mechanical Engineering award is shared by two teams. They are Biofeedback Autonomous Training Simulator, with **Lauren Bergmann**, Fitchberg, Wisconsin; **Andrew Diers**, Ballwin, Missouri; **Will Naquin**, Dallas, Texas; **Hongmin Sung**, Seoul, South Korea; and **Chase Timberlake**, Largo, Florida; and Nissan pick and place smart cart system, with **Jackson Brewer**, Goodlettsville, Tennessee; **Rachel Broadway**, Southlake, Texas; **Mubarak Ganiyu**, Ikeja, Nigeria; **Alex Quinones**, Parrish, Florida; **Mason Slagel**, Ironton, Ohio.

KENNETH A. DEBELAK AWARD FOR EXCELLENCE IN DESIGN

The W. Dennis Threadgill Award is given for outstanding achievement in chemical engineering in honor of a former faculty member and department chair. The award is shared by **Kurt Bertone**, Esmont, Virginia; **Sagar Patel**, Clarksville, Tennessee; and **Anteneh Tebeje**, Southaven, Mississippi.

WALTER C. CRILEY PRIZE

The Walter C. Criley Prize is awarded for the best paper written on an advanced senior project in electrical engineering. The recipient is **Grace DePietro**, Sea Cliff, New York, for the project: Autonomous Manipulator for Defusing Underwater Mines.



In memoriam:
Matthew Walker III, 1964-2021

Matthew Walker III, professor of the practice of biomedical engineering and associate professor of radiology and radiological sciences, died April 24, 2021, at his home.

Walker, 56, designed an innovative biomedical engineering design curriculum that leveraged connections between the School of Engineering, the medical school and the biotechnology community. He served as the biomedical engineering department's immersion coordinator, guiding undergraduate students through their immersion plans and capstone project experiences. He joined the Vanderbilt engineering faculty in 2011.

"Dr. Walker cared deeply about his students, and his innovations made senior design and Design Day into something great. To lose him during his favorite week of the year is heartbreaking," said Michael King, J. Lawrence Wilson Professor of Engineering and chair of the Department of Biomedical Engineering. "A decade of Vanderbilt graduates benefitted from the knowledge and experience he brought from his time in the pharmaceutical industry. Matthew was a beloved educator and colleague, and we already miss his smooth baritone voice and gregarious wit."

Prior to Vanderbilt, Walker worked for Merck Pharmaceuticals for 10 years and co-developed three blockbuster drugs, Vytorin, Januvia and Candesarten. While at Merck, he also led the novel technologies adoption team. He spoke internationally on cardiovascular pharmacology and was working on a book about the interface of technology and personalized medicine.

"He was a genius at turning ideas into a formal design process—ultimately solving complex challenges in health care," said Dr. André Churchwell, vice chancellor for equity, diversity and inclusion and chief diversity officer. "This is a tremendous loss for Vanderbilt."

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The Class of 2021 included the inaugural cohort of Clark Scholars, a program endowed and started in 2017 by a visionary gift from the A. James & Alice B. Clark Foundation. The Clark Scholars Program enables talented undergraduate students to become engineering pioneers who reflect the character, passion and vision of the program's namesake, the late A. James Clark. Back row (L-R): Tim O'Brien, Associate Dean Christopher Rowe, Reese Phillips, Joey Holliday. Front row (L-R): Dean Philippe Fauchet, Adrianna Johnson, Stephanie Schroth, Yoanna Ivanova, Shyla Slater, Irisa Myint. Photo: Emily Mueting

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