2021 - 2022 ANNUAL REVIEW

VCU Engineering

UNCOMMON ENGINEERING

VCU College of Engineering

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Dean's Message

On the heels of celebrating our 25th anniversary, VCU Engineering continues to reach growth milestones that prove our college is only getting stronger. Last year, we welcomed our largest incoming class and this May, we celebrated our largest graduating class, setting a graduation record for the fourth consecutive year.

Our students continue to impress and inspire, proving each day they are qualified, capable and eager to tackle society's grand challenges. From seeking to mitigate age-related bone loss to creating an app to support caregivers of children living with Down syndrome or building a childproof safety mechanism for handguns, our students' passion drives our quest to solve problems for humankind.

> ***Our students continue to impress and inspire, proving each day they are qualified, capable and eager to tackle society's grand challenges.***

Their innovative spirit is nurtured by the guidance of committed faculty who continue to earn national and international distinctions. Our number of faculty NSF CAREER Awards continues to rise. Other faculty members have been appointed director of undergraduate education for the National Science Foundation or have been named incoming president of IEEE's Industrial Electronics Society.

VCU Engineering continues to expand in diversity, both in underrepresented minorities and female students who now make up 29% of our student body. Our programs continue to rise in national prominence with biomedical and mechanical engineering graduate programs now top-ranked nationally. Our online mechanical and nuclear engineering program is considered a best value in the nation.

As you can see, there is much to celebrate at VCU Engineering, so read on and check us out!

Go Rams!

Gary C. Tepper, Ph.D.
Interim Dean, VCU College of Engineering
Professor, Mechanical and Nuclear Engineering

VCU Engineering continues to break records in enrollment, degrees awarded

Record-breaking enrollment fall 2021:

7.3% increase

19% increase in computer science students

Record-breaking graduation

4 YEARS RUNNING

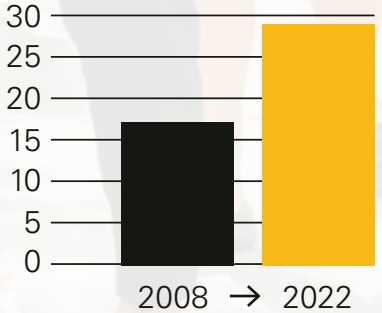
since 2018:

300% increase in student participation in internships and co-ops

Since 2008:

The number of women engineering students rose from

17 to 29%



58% enrollment increase for African American engineering students

60% enrollment increase for Hispanic engineering students

Explore & Tour

VCU Engineering hosted more than 200 families, community partners, volunteers, faculty and staff at Explore & Tour, a STEM-discovery event.

Scan the QR code to see the photos!

BIOMEDICAL ENGINEERING (BME)

Lovell Abraham investigates Alcian Blue Orange G femur fracture cells.

Chemistry major researches how bones change in outer space

BEST GRAD SCHOOLS
U.S.News & WORLD REPORT
ENGINEERING
BIOMEDICAL / BIOENGINEERING
2023

VCU Engineering's biomedical engineering graduate program is ranked among the best graduate schools, according to the 2023 rankings by *U.S. News & World Report*.

In **Lovell Abraham's** first biomedical engineering class, BME professor and chair **Henry Donahue, Ph.D.**, encouraged students to get involved in research. Abraham didn't hesitate and began working in Donahue's lab, winning awards for his contributions to a NASA-funded project studying the effect of microgravity on bone fracture healing.

"We're interested in why astronauts and the elderly lose bone. Bone loss that occurs with space travel is similar to age-related bone loss, which affects millions of people," Donahue said. "Insights into disuse-induced bone loss will possibly lead to new therapeutics for age-related bone loss.

Abraham is looking at a particular cell mechanism called gap junctional communication, where cells talk to one another. He's asking whether inhibiting these gap junctions actually protects against disuse-induced bone loss. Postdoctoral research fellow **Evan Buettmann, Ph.D.**, is leading Abraham in a project looking at how bone fractures heal after the bone has been exposed to disuse.

BIOMEDICAL INNOVATIONS TO ADVANCE PATIENT HEALTH

Researcher seeks to understand how groups of cells determine how and where they are going

BME assistant professor **Priscilla Hwang, Ph.D.**, received a Faculty Early Development (CAREER) Award from the National Science Foundation (NSF) for her research on how cells in the body cluster together and migrate as a group.

This process, called collective migration, is behind the healthy development of many tissues. When wounds heal, for example, cells often gather together and migrate as a "sheet" to help close the wound. But this is not always a good thing. Cancer cells can migrate from the original tumor and travel as a group to form new tumors in the body. This is called metastasis.

Hwang is investigating leader cells, which move to the front and guide the migration of groups of cells. She will study how leader cells polarize to the front of the cell cluster to determine whether leader cells are mechanically connected, and how mechanical forces between leader cells initiate and sustain collective migration. This can provide insight to therapies targeting abnormalities or disease progression that occurs when these migrations go awry.

VCU multidisciplinary researchers seek to improve early detection of aortic diseases

BME assistant professor **John Wilson, M.D., Ph.D.**, and **Uyen Truong, M.D.**, collaborated to test novel imaging methods for assessing a patient's risk of life-threatening aortic dissection, a condition in which a tear can weaken and possibly rupture the aorta.

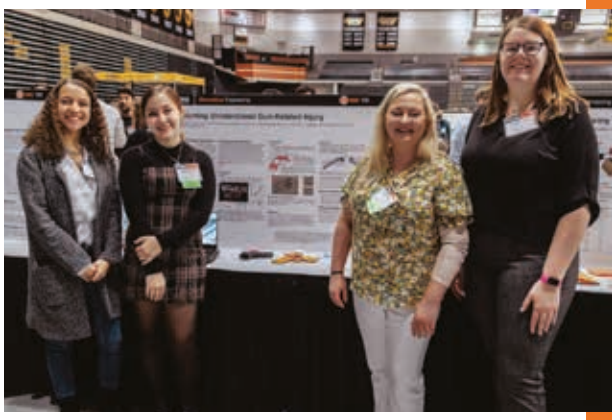
Wilson researches non-invasive MRI approaches to quantify aortic wall strain, which is "a measure of deformation of how the aorta changes in shape as the blood passes through it. We use that information to provide new data that might help clinicians make decisions on how to best diagnose and potentially treat aortic diseases like aneurysms and dissections," he said.

In their joint study of at-risk patients, they are focusing on patients with Marfan syndrome or hypertension. Marfan syndrome is an inherited disorder in which connective tissue, such as that in the aortic wall, can be weakened. Hypertension is also a risk factor for aortic dissections.

Students create prototype of a childproof handgun safety mechanism

From 2015 to 2020, there were at least 2,070 unintentional shootings by children, according to Everytown for Gun Safety. These incidents motivated Capstone team BME106 to choose a senior Capstone Design project related to gun injuries.

BME106 set out to find an engineering solution for two handgun problems: provide ready access to an adult while also preventing a young child from firing it.



Zore X Core is the product BME106 developed, a gun lock with a mechanism that blocks the firing pin from meeting the ammunition and prevents the slide from fully closing. It allows for the lock to stay attached to the firearm and transition automatically to remove the firing pin block.

To prevent children younger than 10 years of age from unlocking the device, the team intends to use mechanical switches or pressure sensors that react only to an adequate amount of force – an amount of force larger than a young child could muster.

Scan the QR code to learn more about Biomedical Engineering at VCU.

Pocillopora damicornis, commonly known as cauliflower coral or lace coral, from the lab of Nastassja Lewinski, Ph.D. Photo courtesy of Liza Roger, Ph.D.

Postdoctoral researcher receives award to conduct coral experiments

Coral bleaching is a threat to coral reefs around the world. **Liza Roger, Ph.D.**, is developing a strategy to mitigate this threat with funding from the 2021 NSF Coral Bleaching Research Coordination Network ECR Training Program and the HDR Award.

Roger is a postdoctoral researcher in the lab of **Nastassja Lewinski, Ph.D.**, CLSE associate professor specialized in sustainable nanotechnologies, who leads coral cell culture research as part of a multi-university team studying corals.

> ***Roger will investigate treating specimens of free-living symbiotic algae with antioxidant nanoparticles to protect them from oxidative stress when living inside coral hosts.***

Healthy corals live in symbiosis with algae in their tissue. However, excess heat or light causes oxidative stress resulting in the breakdown of symbiosis, the expulsion of the algae and the skeleton becoming visible through transparency of the tissue. The process is commonly referred to as coral bleaching.

Roger will investigate treating specimens of free-living symbiotic algae with antioxidant nanoparticles to protect them from oxidative stress when living inside coral hosts.

This delivery method is called reinfection. Roger introduces the algae containing cerium dioxide nanoparticles, a known antioxidant, into bleached corals in hopes the coral will form a new symbiotic relationship with the antioxidant algae and benefit from it. This research has been accepted for publishing in Frontiers of Marine Science.

Researcher works to thwart coronavirus mutations' improved ability to break into the body

CLSE professor **Michael Peters, Ph.D.**, continues researching how to disable "spikes" that give the coronavirus particle its familiar appearance — and its power to prey on cells.

Each spike is composed of subunits called protomers, which have an "up" or "down" state. Like grooves on a key, an "up" state appears to allow binding to human epithelial cells that line the lungs and vasculature, while the "down" state is believed to be relatively inactive.

Forcing protomers into a "down" state may be a step toward future COVID-19 treatments. Peters led research at VCU to map the entire spike protein, looking for points unique to the down state configuration, and identified molecules that may lock it down.

Peters recently published an analysis of the up-to-down states of SARS-CoV-2 variants and lineages, finding that viral variants have protomers appearing to stay in extended "up" states. This study also identified common glue points for the down states, which could be critical in tracking future variants and lineages. Peters and collaborators are also working to block spike protein binding using a novel peptide mimicking the way the virus binds to the cell's surface.

National Institute for Pharmaceutical Technology and Education welcomes VCU Engineering

The National Institute for Pharmaceutical Technology and Education (NIPTE) recently gave membership to VCU's College of Engineering, increasing and expanding NIPTE's scientific and technical capabilities in the areas of advanced active pharmaceutical ingredient (API) manufacturing and enabling collaboration with key industrial and federal partners.

> ***More recently, we have applied these same principles to address the global supply chain vulnerability for essential medicines highlighted by the COVID-19 pandemic.***

"Several years ago, the Medicines for All Institute at the VCU College of Engineering began working with the Bill & Melinda Gates Foundation with a goal of increasing access to medicines for the treatment of HIV, malaria and tuberculosis by developing more cost effective methods for the production of APIs. More recently, we have applied these same principles to address the global supply chain vulnerability for essential medicines highlighted by the COVID-19 pandemic," said **B. Frank Gupton, Ph.D.**, CEO, Medicines for All Institute and the Floyd D. Gottwald, Jr. Chair in Pharmaceutical Engineering; professor and chair of CLSE.

Researchers add air pollution measurements to map of Richmond

CLSE professor **Stephen S. Fong, Ph.D.**, led a group of students and volunteers in 2017 to find where Richmond's highest temperatures were during a heat wave. Researchers are now working to generate additional layers for that map, showing measurements of two forms of air pollution: particulate matter — tiny pieces of soot and other contamination — and ozone.

Efforts to develop the award-winning heat map that demonstrates the urban heat island effect gained national attention in discussions about the hottest parts of cities in modern times and the legacy of redlining policies.

To better understand what, in addition to extreme heat, may be impacting the health of residents in various neighborhoods, VCU and others have begun measuring air quality.

Seemingly minor increases in air pollution are multiplied because of their cumulative effect. Fong said, "There's growing evidence that long-term exposure to elevated levels of air pollutants can lead to noticeable cognitive impairment."

Scan the QR code to learn more about Chemical and Life Science Engineering at VCU.

Image illustrating ICLN protein and disordered regions at the bottom and in the top-right corner.

Researchers develop award-winning method to predict intrinsic disorder in proteins

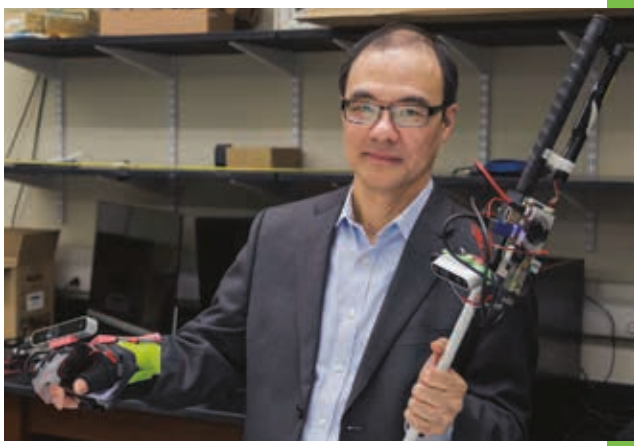
Lukasz Kurgan, Ph.D., the Robert J. Mattauch Professor and vice chair of CS, and a team of his doctoral students and collaborators won first place in Critical Assessment of Protein Intrinsic Disorder Prediction (CAID). This worldwide challenge was established to identify the most accurate methods that predict unstructured protein regions, which have been found to be associated with cancers, cardiovascular and neurodegenerative diseases.

The Kurgan team's entry, called fIDPnn, outperformed a record-breaking pool of 32 methods developed across the world. The results were published in the Nature Methods journal.

CS doctoral students **Akila Katuwawala** and **Sina Ghadermarzi**, along with collaborators from Nankai University in China, contributed to the development of fIDPnn. It predicts intrinsic disorder using a deep neural network that relies on a sophisticated approach to encode network inputs derived from protein sequences.

This method is the culmination of more than a decade of research, most recently sponsored by the National Science Foundation. It has since been featured in the journal Nature Communications.

SOLVING COMPLEX PROBLEMS



Computer science professor wins funding to help secure nuclear energy infrastructure

Milos Manic, Ph.D., CS professor, has been named president-elect of the Institute of Electrical and Electronics Engineers Industrial Electronics Society. As director of the VCU Cybersecurity Center, Manic recently received $200,000 from the Idaho National Laboratory (INL) to develop technologies to integrate and secure critical systems for nuclear power.

Manic and his collaborators are working on a digital engineering approach using computer and mathematical sciences to integrate systems with asset engineering, design and operations. The VCU team is working on statistical and AI-based systems analysis. Their goal is to provide advanced automation and analytics for more secure nuclear energy infrastructures.

This multi-institution project is expected to deliver $1 billion in reduction of anticipated costs and a 25% productivity increase using virtual design and construction, reducing errors and risk in the design of complex systems.

Computer science major helps create app for caregivers of children with Down syndrome

Jeffrey Duah, a CS graduate, had the opportunity to experience the iterative process of software development through projects from the VCU Isosceles Lab run by Department of Information Systems Associate Professor **Elizabeth Baker, Ph.D.**

One project came from the University of North Carolina Chapel Hill School of Nursing (UNC), where it was observed families who have children with Down syndrome often see multiple medical providers. The families can have a difficult time keeping track of doctors, medical records and appointments.

Duah's team worked with UNC to build an app for keeping this important information organized. User testing app functionality with the families alongside general usability testing made sure the platform was robust yet simple to operate.

Scan the QR code to learn more about Computer Science at VCU.

Robotic cane with a 3D camera brings navigation assistance to the 21st century

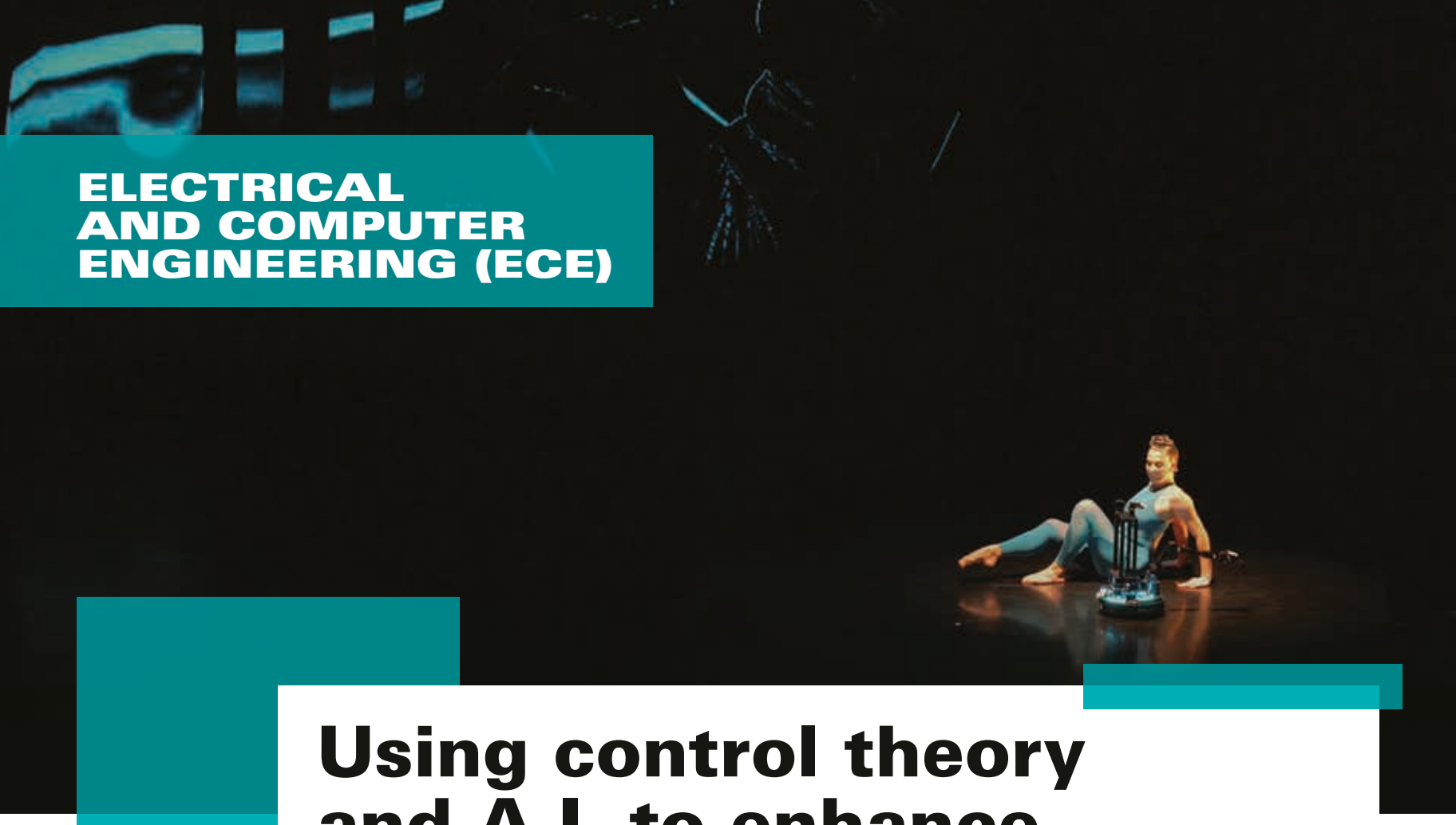
Equipped with a color 3D camera, an inertial measurement sensor and its own on-board computer, a robotic cane could offer blind and visually impaired users a new way to navigate indoors. When paired with a building's architectural drawing, the device can accurately guide a user to a desired location with sensory and auditory cues, while also helping the user avoid obstacles like boxes, furniture and overhangs.

Cang Ye, Ph.D., CS professor, wants to optimize assisted navigation. Over long distances, location inaccuracies could leave the user at the wrong place. Ye and colleagues added a color depth camera to help correct this. The system determines the distance between the cane and other physical objects. This technology allows the onboard computer to map the user's precise location.

UNDERGRADUATE CONCENTRATIONS

CYBERSECURITY
DATA SCIENCE
SOFTWARE ENGINEERING

ELECTRICAL AND COMPUTER ENGINEERING (ECE)



Using control theory and A.I. to enhance human-robot interactions

(Pictured above)
A robot built by the lab of Patrick J. Martin, Ph.D., learns new motions from its human dance partner and assembles a performance.

> ***Roboticists have much to learn from dancers and choreographers, who are experts in expressive motion and coordination.***

Patrick J. Martin, Ph.D., ECE assistant professor, uses control theory and A.I. to safely deploy distributed autonomous systems. He recently applied these concepts to a dance collaboration between a human and a robot.

In a recent Q&A, he explained:

Roboticists have much to learn from dancers and choreographers, who are experts in expressive motion and coordination. Architectural and algorithmic outputs from this research will inform how we integrate autonomous robots into situations where there are multiple humans and robots working together.

This research, in collaboration with VCUarts, focuses on two aspects: 1) learning new motions from humans and 2) assembling a performance from multiple robot behaviors. This algorithm uses machine learning to extract key parameters of demonstrated motions and allow the user to mix these parameterized motions to achieve different expressive motifs, such as tempo. Combining these two capabilities provides a framework for more flexible human-robot choreography.

Scan the QR code to learn more about Electrical and Computer Engineering at VCU.

DEVELOPING INTELLIGENT TECHNOLOGIES

Making it [virtually] real, demonstrating the invisible physics behind everyday processes

ECE associate professor **Nathaniel Kinsey, Ph.D.**, noticed even strong math students missed the big picture behind Wi-Fi, EZ passes and other electromagnetic processes, so he created interactive computer simulations demonstrating advanced math and physics concepts.

These teaching methods were featured in an IEEE Spectrum magazine supplement. **Simon Woodruff, Ph.D.**, from SciVista, saw the article and offered to help turn the simulations into virtual reality (VR) experiences.

Woodruff and Kinsey prototyped a platform that takes electromagnetic simulations into VR. Future enhancements include virtual lecture rooms where participants' avatars can play with 3D models in real time.

Researchers develop 5G communications system to enable smart warehouse technology

Wireless technologies to help locate and inventory items are important for supply chain logistics. As facilities grow, "smart warehouses" using these technologies are essential.

Ruixin Niu, Ph.D., ECE associate professor, works to optimize these systems as principal investigator on a 5G smart warehouse project to design a distributed wireless system to enhance communications capabilities for smart warehouses.

Working with ECE associate professor **Yanxiao Zhao, Ph.D.**, their system design for wireless communications is based on distributed coherent multiple-input multiple-output (MIMO) technology, which increases overall performance.

Distributed systems are attractive in smart warehouse design because they are less expensive to scale if a facility is enlarged. They are also more reliable because they are made up of multiple nodes and don't experience disruptions if a single node fails.

The Dreams to Reality Incubator: open for business

The Dreams to Reality Incubator (D2Ri) is where students, faculty and local businesses develop partnerships for introducing new products to market. D2Ri opened its laboratory in the Engineering Research Building this year. Five companies were showcased at the ribbon cutting, two which are funded by the Commonwealth Cyber Initiative (CCI).

Erdem Topsakal, Ph.D., professor and interim senior associate dean, championed the D2Ri's formation. He dreamed of increasing innovation in Virginia by creating a space for faculty, staff and students to build and understand the steps in creating a successful business.

VCU Engineering professor leading National Science Foundation's Division of Undergraduate Education

The National Science Foundation appointed **Rosalyn Hobson Hargraves, Ph.D.**, to be Division of Undergraduate Education director. Hargraves, an ECE professor, is a recognized leader in advancing equity, excellence and inclusion in STEM. She works to advance the division's mission to promote excellence in undergraduate science, technology, engineering and mathematics education for all students at two-year and four-year institutions.

MECHANICAL AND NUCLEAR ENGINEERING (MNE)

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2023

Our mechanical engineering graduate program is top-ranked by *U.S. News & World Report* and our MNE online master's program has been named one of the best values for online education in the nation according to Best Value Schools.

Building a better face mask

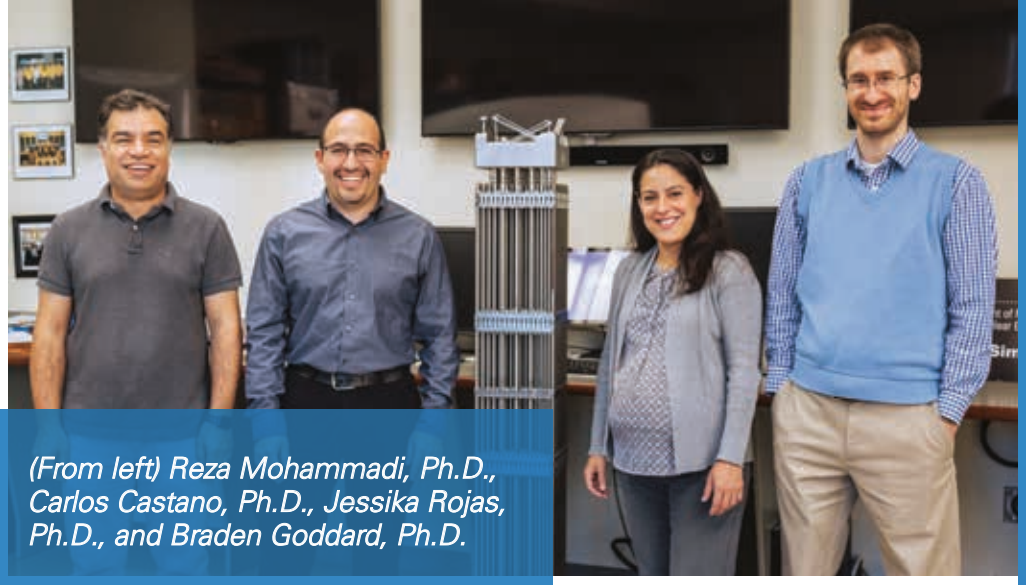
Highly contagious new COVID-19 strains call for better masks. MNE associate professor **Wei-Ning Wang, Ph.D.**, is working to meet this need with a mask design that uses chemical reactions and electrical charges to kill microbes.

> ***The middle layer catches virus particles with the same efficiency as N95 masks. Most particles will never make it past the outer layer, where the virus killing occurs ...***

The mask's innermost layer also absorbs water vapor. "Human exhalation is saturated with water vapor, so it has 100% relative humidity," Wang said. "This means that these vapors will condense inside the face mask, causing discomfort." A mask that effectively absorbs those vapors will keep the wearer cooler and dryer — no more foggy eyeglasses.

The middle layer catches virus particles with the same efficiency as N95 masks. Most particles will never make it past the outer layer, where the virus killing occurs, because it is made of electrospun nanofibers embedded with nanocrystals containing an antibacterial and antiviral ammonia compound often found in detergents.

In other words, the researchers are developing a material designed to poison and electrocute the COVID-19 particle. The chemicals and other components of this material are nontoxic, low cost and reusable.



(From left) Reza Mohammadi, Ph.D., Carlos Castano, Ph.D., Jessika Rojas, Ph.D., and Braden Goddard, Ph.D.

Student Standouts

Congratulations to these MNE students.

Department of Defense SMART Scholars:

Lars Axberg
Tristan Norrgard

Department of Energy University Nuclear Leadership Program Scholars:

Lucas Diehl
Sierra Tutwiler

VCU Engineering team investigates advanced materials for reactor safety

The Nuclear Regulatory Commission has funded a research team led by **Jessika Rojas, Ph.D.**, MNE associate professor, to investigate the behavior of nuclear materials with the aim of improving safety and performance for the U.S. nuclear power fleet. The team will analyze the behavior of candidate materials being considered for fabrication of nuclear fuel claddings.

Under investigation are iron-chromium-aluminum (FeCrAl) and a chromium-coated zirconium alloy (zircaloy), "smart materials" engineered for enhanced oxidation resistance at high temperatures and better material performance over a wide range of reactor conditions.

Laboratory experiments and computer simulations will enable the team to study the oxidation, degradation, and mechanical behavior of accident-tolerant fuels cladding candidates subjected to rapid high-temperature excursions and dry storage conditions.

Advanced materials for NASA missions in space

Ibrahim Guven, Ph.D., MNE associate professor, is part of a team working with NASA to develop an advanced structural material for a crewed mission to Mars.

Spacecraft transporting humans to deep space must withstand extreme changes in temperature and air density while also resisting potentially devastating impacts when hitting even tiny particles.

Guven and his collaborators have been developing material, based on carbon nanotube composites, strong enough to be safe but lightweight enough to be practical when sending humans into deep space. This material will ultimately be used as the main load-bearing fuselage of a spacecraft. It would also be suited for cargo containers transporting samples and other items back to Earth.

Doctoral student receives 2021 Innovations in Nuclear Technology R&D Award

Dimitris Killinger, MNE doctoral student, received this award from the U.S. Department of Energy's Office of Nuclear Fuel Cycle and Supply Chain. His paper shows the performance of electrode materials in electrochemical techniques for real-time measurements of nuclear elements in advanced reactor technologies.

Scan the QR code to learn more about Mechanical and Nuclear Engineering at VCU.

VCU Engineering students display their projects to the Greater Richmond community during the annual Capstone event. This culmination of undergraduate education sees teams use learned skills to solve real-world problems.

Capstone Design Expo

More than 375 students participated in this year's Capstone Design Expo, the signature event of the VCU College of Engineering. This annual event represents the culmination of the senior class's education and offers design teams the opportunity to display and demonstrate their working prototypes to the Greater Richmond community.

The projects are the product of a yearlong Capstone Design course which immerses senior engineering students in the hands-on processes of solving practical real-world problems.

Through their projects, student teams practice customer discovery, the engineering design process and rapid prototyping. Working with sponsors, students tackle this practical learning experience by solving real-world problems under real-world constraints, learning fundamentals of teamwork and applying learned theory.

Several teams earned honors at the 2022 Capstone Design Expo including Excellence in Design Awards that range from 3-D modeling to data sharing, water treatment and more; to the Best Industrial Project that will help online authors become more profitable through data analysis; and the project to measure finger tap, tremor and rigidity during DBS surgery that took both the Dean's Choice and the People's Choice Awards.

VCU College of Engineering receives $1 million grant from Bank of America

This year, Bank of America strengthened its partnership by making a $1 million anchor grant to the VCU College of Engineering. The grant supports K-12 programs that attract students to engineering careers, helping build their confidence to pursue a technology education. This grant also provides programs to support students through college, helping them cross the finish line to graduating with engineering or technology degrees.

$1M

BANK OF AMERICA GRANT FURTHERS STEM EDUCATION

This is the latest in a partnership to increase access and participation in engineering, data science and computer science education at VCU and partnering institutions. Bank of America and VCU Engineering believe collaboration between the academic and business communities is essential to expand education pathways and create programs to ensure the success of students from diverse communities.

Navigating the nanoscale

The Nanomaterials Core Characterization Facility (NCC) is part of VCU's Office of Research and Innovation. Housed in the Institute for Engineering and Medicine, it helps researchers see and modify nanoscale materials. A partnership between VCU's Colleges of Engineering and Humanities and Sciences, it is a resource for users at VCU, and from industry across the U.S. and abroad.

Instruments to investigate this tiny realm are costly. Bring those instruments and infrastructure together, and you have the NCC, one of the best-equipped nanomaterials characterization centers in the mid-Atlantic region.

State-of-the-art technologies available in the NCC include:

- Scanning Electron Microscopy (SEM) and Field Emission SEM
- Focused ion beam
- X-ray diffraction (XRD) and thin film XRD
- DynaCool physical property measurement system (PPMS)
- Angle-resolved X-ray photo spectroscopy (XPS)
- Micro- and nano-CT scanning
- X-ray fluorescence (XRF)
- Atomic force microscopy (AFM)
- Transmission electron microscopy (TEM)
- Laser scanning microscopy (LSM)
- Raman spectroscopy

Beyond the sophisticated instruments, the NCC's team of scientists provides analytical expertise. **Researchers interested in collaborating may email ncc@vcu.edu.**

Scan the QR code to learn more.

Nanoscale view of polyester fibers engineered with Cupron, an antimicrobial nanotechnology based on copper. Photo courtesy of Cupron.

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