MechSE News

MECHANICAL SCIENCE AND ENGINEERING / FALL 2019

ILLINOIS

Introducing the Sidney Lu Mechanical Engineering Building

MechSE students in front of the under-construction Sidney Lu Mechanical Engineering Building: (from left) **Rahul Ramkumar, Karina Herrera, Sevan Brodjian, Richard McClure, Madison Yang, Yamini Yetedore, Ben Haytcher, Sebastian de la Torre, Kirsten Polen, Nick Bahr, Eric Roman,** and **Ryan Jacobs**.

The Mechanical Engineering Building (MEB) at the University of Illinois has been renamed the Sidney Lu Mechanical Engineering Building, after receiving approval by the Board of Trustees on May 16.

"It is impossible to overstate the importance of Mr. Sidney Lu's impact on the Transform MEB project," said MechSE Professor and Department Head **Tony Jacobi**. "The generosity he has shown to ensure an incredible facility for education and innovation has taken the project from a dream to a reality. He truly wants MechSE students to have an unrivaled experience during their years at Illinois."

In 2014, Mr. Lu was informed of the "Transform MEB" project and immediately became its biggest champion. He has now donated $21.5M to the $41M project, bringing it to within $3.5M of being fully funded.

Construction on the project—which includes a 25,000-sqft east wing addition, a second addition making lab space out of an interior courtyard, and the creation of multiple modern classrooms and student labs within the existing space—began May 6.

The project is scheduled to be completed in the summer of 2021, in time for Fall 2021 classes. Current freshman and sophomore students—some of which are pictured above—will be here to enjoy the new facility, which is dedicated to undergraduate labs and classrooms. Additional lounge areas, gathering spaces, a student center, and a coffee shop will be utilized by the entire MechSE community.

The project's pillars all along have been education, innovation, and community. With ground broken and a very fitting renaming complete, these pillars will soon be evident for all to embrace and enjoy.

"We are beyond excited to be renaming MEB as the Sidney Lu Mechanical Engineering Building," Jacobi said. "The impact of his gifts will benefit MechSE students for many generations to come."

Engineering Visionary Scholarships bring awesome engineers to MechSE

MechSE

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just go to mechse.illinois.edu!

In partnership with The Grainger Foundation, The Grainger College of Engineering has raised $96.6 million of its $100 million goal to provide unrestricted scholarships to engineering students—attracting the brightest students and ensuring a diverse and talented class. The Engineering Visionary Scholarship Initiative has enabled hundreds of deserving students to nurture their ambitions and turn their passions into possibilities.

"I have this incredible life now that is enabled by my MechSE degrees, and I got it for basically nothing but my time and effort. The matching program from The Grainger Foundation was the motivating factor to get the ball rolling to give back. Getting $4 of scholarship for every $1 that I contribute was too good to pass up."
–**Lance Hibbeler** (MSME '09, MSTAM '11, PhDME '14) launched the Lance C. Hibbeler Mechanical Science and Engineering Visionary Scholarship Fund.

Make an exponential impact

There has never been a better opportunity to support the future of MechSE. Thanks to The Grainger Matching Challenge, qualifying gifts and commitments made to the EVS Initiative will be matched, now through **December 31, 2019** or until matching funds remain.

Find out more

Betsy Rodriquez
Associate Director of Advancement
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grainger.illinois.edu/giving/evs

What our scholarship recipients are saying...

"With four children in my family and no chance of paying out of pocket, college has been quite the financial challenge. The scholarship I received took an indescribable burden off my family. Rather than taking a tremendous amount of funds out in loans that will hold my parents and myself back for years or decades to come, my family now has far less to worry about when it comes to finances and being secure."
–**Sevan Brodjian**

"I am very grateful to all the donors who have helped me in my first year of the college experience. I plan to repay their generous donation by succeeding academically, volunteering locally whenever I can, and making the most of all the opportunities available to me."
–**Ian Kinsel**

▲ Introducing The Grainger College of Engineering

The Grainger Foundation's total support represents the largest amount ever given to a public university to name a college of engineering, with more than $300 million provided in total. The college has been named in recognition of the contributions of The Grainger Foundation to the excellence of the college and in honor of distinguished alumnus William W. Grainger.

▲ Sophomore's startup shines at Cozad

MechSE sophomore **Mark Van den Avont**'s company, HexNest, captured second place out of 56 finalist teams at the 2019 Cozad Competition, which encourages students to innovate and create new businesses. HexNest is developing a sports/gymnastics mat that will cost less than those currently on the market, making the equipment more accessible. It will also have a safer design.

◀ Formula team making noise in 2019

Illini Motorsports FSAE is coming off numerous top-ten event finishes in both the FSAE Michigan and Lincoln competitions in 2019. Among these was a third-place finish in engineering design among 80 combustion teams at Lincoln, the team's best-ever finish. As they enter the new competition season, they have begun finalizing design on their third-generation composite monocoque, updated drivetrain, and all-new engine control and data logging system. "Along with these major changes to vehicle architecture come a new aerodynamics package and focus on full-vehicle simulation capability," said team captain **Stephen Bosch**. "The team has their sights set on another successful season!"

▲ Eco Illini win Shell competition

The Eco Illini was awarded first place among the 22 teams participating at the Shell Eco-Marathon Americas competition in Sonoma, California. The team's efficiency of 152 mi/kWh, approximately 5,123 miles per-gallon-equivalent, set a new school record. The Shell Eco-Marathon competition tasks teams with achieving their highest efficiency using their specific type of energy. This year was Eco Illini's first time with an all-electric drivetrain, having previously competed with an internal combustion engine.

◀ Wise's startup raises another $46M in funding

Fetch Robotics, the startup of MechSE alumna Melonee Wise (BSME '04, MSME '06), raised $46 million in venture capital in July, bringing its total funding to $94 million. A member of the department's alumni advisory board, Wise received the MechSE Distinguished Alumni Award in 2016.

M.Eng.ME program preparing students for industry

MechSE's professional master's degree program, the Master of Engineering in Mechanical Engineering (M.Eng.ME), has received several upgrades heading into 2019-20.

Previously directed—along with the MS and PhD programs—by MechSE's associated head for graduate programs, the M.Eng.ME program now has its own dedicated faculty director in Teaching Assistant Professor **Jiajun He**. He has been working with Associate Head **Taher Saif** and Department Head **Tony Jacobi** to advance several aspects of the program.

"To actually enhance the experience of the students and get them better prepared for future jobs, we developed new courses and we invited industrial experts to teach those courses," He said. "For example, we have Dr. **Kevin Wise** from Boeing who is teaching a course on control systems for aerospace applications."

In addition to experts from industry, MechSE faculty are teaching courses that are closer to what students will experience on the job. One of them is a capstone design course, ENG 573, in which students work with companies on real-world engineering challenges.

Another is ME 598, a catch-all course for "special topics" that faculty members customize. One ME 598 section, "Fun with Mechanics," is a two-semester elective course taught by Professor Emeritus **Darrell Socie.** He creates an industry-analogous environment with industry-level expectations.

With three people in each group, Socie tasks the students with designing and building drill-powered vehicles that compete in a race around the Bardeen Quad at the end of the spring semester. The students design the vehicle in the fall semester, which leaves the spring semester for manufacturing. The course requires students to submit monthly progress reports to Socie, compile a purchasing list by the end of the fall semester, and produce a functioning final product by the day of the race.

The experience gives students a project that they can take true ownership of from start to finish.

The team must be accountable for scheduling their time and ensuring that they are making adequate progress to finish the task. They are in charge of ordering the purchased parts and materials for their vehicle, which requires that they consider lead times, quantities needed, and other concerns.

Socie views the progress reports as a valuable way to demonstrate the expectations students will need to meet in their future jobs.

"In the beginning I spend a lot of time with them describing the difference between what you did and what you accomplished," Socie said. "Initially, a lot of the students just want to fill out the report and so they include a lot of trivial things that they did. And if you go out to work and you fill up a page with trivial things and give it to your boss that's going to put big red flags in front of him that you haven't accomplished anything and your project isn't progressing."

The design project itself poses many engineering challenges for the students. The vehicles need to hold a driver, so the scale of the project is much larger than what most students are used to. This can cause a lot of unforeseen challenges with all of the forces and considerations being of a greater magnitude than what they have previously encountered.

"There are all kinds of real life lessons that I try to teach in the class," Socie said. "Those are the types of lessons that you keep for a very long time, and that's the benefit of classes like this. You learn."

Students participate in the final competition of ME 598 in Spring 2019, racing around the Bardeen Quad in vehicles they built themselves.

Illinois awarded NRT grant for materials/data science program

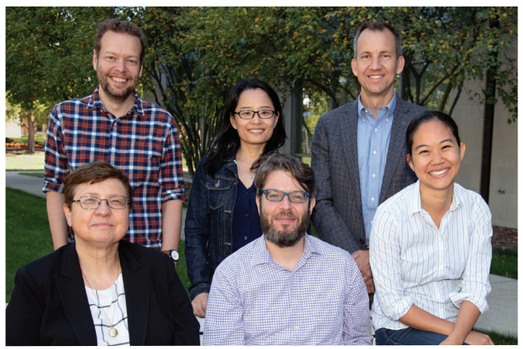
The University of Illinois at Urbana-Champaign has been awarded a National Science Foundation (NSF) Research Traineeship (NRT) grant to begin a PhD-level certificate program, which combines materials and data science.

"This allows us to essentially plant a flag in that area and really train a new generation of graduate students," said MechSE professor **Harley Johnson**, the Associate Dean for Research for Illinois' Grainger College of Engineering and the principal investigator of the project. "The internship part of the program is unique and sets us apart even from the other NRT programs around the country."

Johnson notes that he has heard from both domestic and international partners in industry and at national laboratories of a real need for highly trained PhD-level individuals knowledgeable in both areas as part of their workforce. Those partners cover a spectrum of industries, including manufacturing, transportation, automotive, aerospace, health care (materials for medicine), and energy.

"Even before we put this team together, they were coming to us and asking how can we grow a pipeline of PhD researchers who know these topics," Johnson said. "We have a large enough network that we should be able to match students with partners closely related to their PhD programs so that it won't delay their degree progress. They'll leave with strong connections that could lead to jobs. We also expect new collaborations between faculty and these partners."

Johnson adds that the materials research ecosystem spanning a number of engineering departments and interdisciplinary research units combined with a leading high-performance computing infrastructure make the University of Illinois the ideal institution to grow the program.



The NRT materials/data science team includes (back row from left) **Lucas Wagner** (Physics), Bo Li (CS), and **Harley Johnson** (MechSE, Associate Dean for Research). (Front row from left)**: Klara Nahrstedt** (CS, Director of Coordinated Science Laboratory), **Dallas Trinkle** (MatSE), and **Pinshane Huang** (MatSE). Not pictured: **Lorna Rivera** (NCSA), **Luke Olson** (CS), **Elif Ertekin** (MechSE), and **Matthew Turk** (Information Sciences).

MechSE alumnus Basu to head Cancer Treatment Centers of America

MechSE alumnus **Pat Basu** (BSME '00), MD, MBA, has been named the new President and CEO of the Cancer Treatment Centers of America.

Basu's previous roles include President, Chief Operating Officer, and Chief Medical Officer at vRad, and President and Co-Founder of Doctor on Demand. It's an illustrious career, especially considering Basu is only 40 years old.

He credits his engineering education for much of his success.

"There are a few distinct things that mechanical engineering gave me that has applied to every aspect of my career," Basu said. "One is just a constant lens toward optimization. I literally cannot walk down a hallway or building without kind of thinking, is there a better way to do that? So it's just a constant innovation and improvement mentality which has served me very, very well.

"The second aspect I would say is a real systems-level approach to things. How do you build a system that is reliable and consistent and dependable? It's a lifelong professional mission to build a better American Healthcare system, and by extension a better America, because it impacts so much of us on such a big scale. I think of systems, and this traces back to my engineering, if you build a really good system, it can account for human error, it can account for mistakes. But if you build a bad system, it doesn't matter if you've got great people or things like that, the system will lead to bad outcomes.

"The third is probably equally important in life. It has just given me an unbelievable perseverance to be able to say, 'I've done hard things before. I can do this again.' Just in my life, there's been tough times in med school, having to learn 8,000 drugs and 4,000 diseases in three weeks. I'd look back and say, 'You know what? I've done harder things at Illinois Engineering.'"

Sofronis expands Illinois partnership with Kyushu University

Dignitaries on hand for the MOU signing included (left to right): **Rashid Bashir**, Dean of The Grainger College of Engineering; Illinois Provost **Andreas Cangellaris**, Illinois Vice Provost **Reitumetse Obakeng Mabokela**, Illinois Chancellor **Robert J. Jones**, Kyushu President **Chiharu Kubo**, Kyushu Executive Vice President **Masato Wakayama**, and MechSE professor **Petros Sofronis**, Director of I²CNER.

In 2010, two of the world's leaders in energy research, the University of Illinois at Urbana-Champaign and Kyushu University in Japan, formed the International Institute for Carbon-Neutral Energy Research (I²CNER, pronounced ICE-ner). Through funding from Japan's Ministry of Education, Culture, Sports, Science, and Technology (MEXT), the two universities have spearheaded a global effort to advance low-carbon emissions and cost-effective energy systems and the improvement of energy efficiency.

With the 10-year agreement set to expire on March 31, 2020, the universities have decided to take the framework of the agreement and expand it to other colleges and initiatives through a Memorandum of Understanding (MOU).

"The expanding collaboration between the University of Illinois and Kyushu University provides an excellent opportunity to build on the 10-year relationship our universities established through I²CNER, to capitalize on our mutual strengths as we broaden our engagement and explore innovative solutions to pressing global problems," said **Reitumetse Obakeng Mabokela**, Illinois' Vice Provost for International Affairs and Global Strategies.

"By establishing a strategic partnership with the University of Illinois, Kyushu University hopes to be able to link research and education in a wider range of academic and human resource development fields in addition to existing strong cooperation in the energy field," said **Masato Wakayama**, Executive Vice President of Kyushu University. "Through this ambitious and unprecedented collaboration with the University of Illinois, Kyushu University strongly hopes to promote activities that contribute to academic progress and the sustainable development of mankind."

"When it comes to research in the area of hydrogen materials interactions, Illinois has been a world leader for the past 50 years," said **Petros Sofronis,** the Director of I²CNER and the James W. Bayne Professor of Mechanical Science and Engineering at Illinois. "Kyushu, at the same time, is internationally recognized for its outstanding research program underlying all aspects of hydrogen technology and has some of the world's best hydrogen research facilities. Having such highly respected universities leading the charge is why I²CNER has been so successful. For instance, we have been the catalyst for fuel cell cars, which could reduce the carbon emissions in Japan by 0.42%, equivalent to taking seven million gasoline-powered vehicles off the road by 2050. Also, we are working toward effective, efficient methods of turning CO_2 into useful products, which provides the opportunity to contribute to solving the climate crisis."

Argonne and Illinois to fuel further technology development

The U.S. Department of Energy's (DOE) Argonne National Laboratory and the University of Illinois's Grainger College of Engineering have announced the formation of the Midwest Hydrogen and Fuel Cell Coalition. MechSE professor **Petros Sofronis** will head the new coalition.

"This partnership with Argonne is just the beginning of what we hope will become a Midwest energy hub," Sofronis said. "It may expand quickly to include the University of Wisconsin-Madison, Northwestern University, Purdue University, as well as industrial partners."

Fuel cells, which combine hydrogen and oxygen to produce electricity, heat, and water, can be used in multiple sectors for transportation, stationary power, and industrial applications.

"There is an outstanding tradition of research in The Grainger College of Engineering in the area of hydrogen interaction with materials that dates back to the 1980s," said Dean **Rashid Bashir**. "We are moving this tradition to the next level from the basic science to alloy and device development."

There is great potential for hydrogen and fuel cells to provide energy resilience and security, reduce emissions, and foster economic growth, according to **Ted Krause**, Argonne's Fuel Cell Laboratory Program Manager and a department head with Argonne's Chemical Sciences and Engineering Division.

$100M C-NICE Center launched at Illinois

The University of Illinois's Grainger College of Engineering and Foxconn Interconnect Technology (FIT) are partnering on a new $100 million Center for Networked Intelligent Components and Environments (C-NICE). The center, based on the university's campus in Urbana-Champaign, will serve as a global hub for the smart, reconfigurable technology that will drive the manufacturing plants, medical environments, autonomous vehicles, and smart homes of the future.

MechSE professor **Placid Ferreira** will be C-NICE's founding director, and MechSE alumnus **Sidney Lu** (BSME '81) is the CEO of FIT.

C-NICE launched October 1, and is headquartered in The Grainger College of Engineering's Coordinated Science Laboratory, one of the nation's oldest and most prestigious interdisciplinary university research laboratories.

"It's with great excitement we announce the company that I am so proud of and the university that touched my life coming together to create the Center," Lu said. "By co-developing intelligent components and technologies and the eco-system in which they operate, we can do the same for any number of devices and environments like factories, cars, homes, and hospitals. The potential impact technology has on the future is limitless."

C-NICE will be supported by a $50 million, 10-year commitment from FIT to fund programs and research, the first of its kind for FIT. The university, meanwhile, will partner with the Discovery Partners Institute (DPI) and Illinois Innovation Network (IIN)—statewide initiatives led by the U of I System to foster discovery and innovation—to invest $50 million to expand facilities to house the C-NICE center and research infrastructure and to hire faculty to advance the research and translational efforts.

Collaborative teams made up of researchers from FIT and the University of Illinois will work together on a broad array of projects, selected and funded on an annual basis, as part of C-NICE.

"Illinois has a very strong tradition in fundamental research, and FIT is very strong in product engineering, product development, and translating

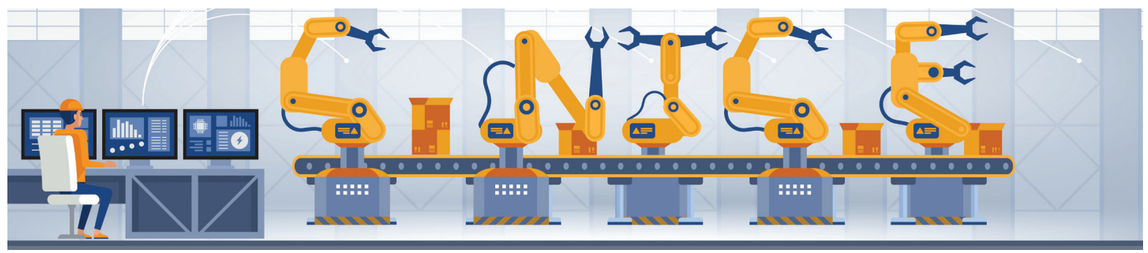
MechSE professor Placid Ferreira with MechSE alumnus Sidney Lu.

good sound engineering into products," Ferreira said. "And so the two of us working together will be able to really compress the life cycle of good ideas going into new products, new product ideas, and new manufacturing solutions. That's where the synergy for such a center lies."

Potential projects include ones designed to advance aspects of FIT's core businesses for the computing, communication, and sensing infrastructure that constitute the backbone of the Internet of Things—enabled systems and environments. Other projects could include precision components, such as electronic and optoelectronic connectors (like a network cable or HDMI cable), antennas (like those used in a cell phone), sensors (like those that cars use to park themselves), and parts used in digital cameras. Additional forward-looking projects exploring advances for next-generation communications infrastructure, consumer electronics, and mobile devices for the intelligent, safe environments of the future could be selected.

"Today we are realizing that connectivity, data, and ubiquitous computing have to come together in powerful platforms," Ferreira said. "We need to integrate smart hardware components like shop floor machines, medical devices, smart phones, and many others so they connect up with each other and actually share data, models, and behaviors, so we have a much more intelligent ecosystem of devices.

"We hope teams of Illinois professors and students can work in very close collaboration with FIT engineers, and learn from each other."



Ramos's humanoid robots push boundaries of controls

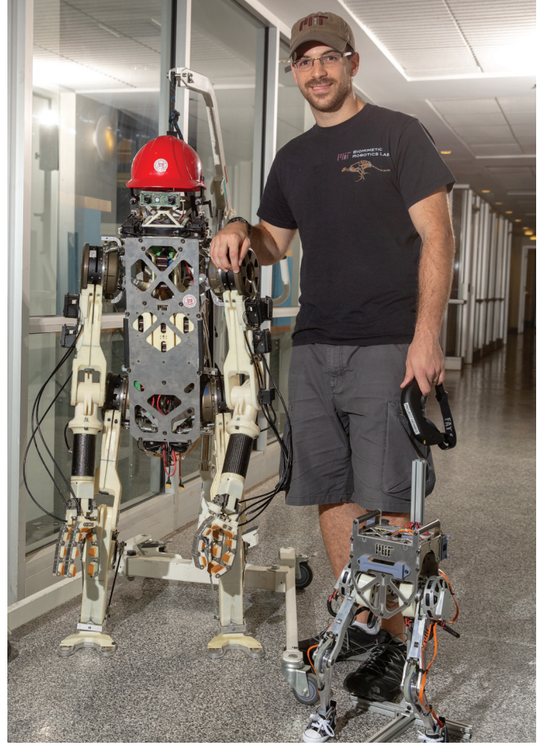
Assistant Professor **João Ramos** joined MechSE in August 2019, after earning his PhD and completing a postdoctoral appointment at MIT.

Ramos said he was drawn to Illinois because of its strong history in controls and robotics theory. He believes his hardware experience complements many of the skillsets of faculty in The Grainger College of Engineering.

In his current research, Ramos hopes to develop high-performance humanoid and other mobile robots that he can push to their limits to perform physically demanding tasks, with special focus on the robot's hardware. In part to avoid long-standing challenges on the controls side of robotics, Ramos uses human operators to control his robot. The first part of his research focuses on utilizing human motor control intelligence paired with whole-body haptic feedback from the robot to teach the operator how to control the physical interactions between the robot and its environment and understand what it's experiencing.

"I think that if you can give a person the right way to communicate with the robot, then anyone can learn how to control it," Ramos said. "It's pretty much like learning how to play a new sport: in the beginning, it's complicated because you have to deal with this new system, but when you learn its dynamics you're able to do something that we didn't even imagine the robot could do."

Once Ramos has achieved the proper communication channel between operator and robot, he aims to challenge the robot's locomotive capabilities and focus on what he calls dynamic mobile manipulation—which are tasks that involve whole-body coordination to manipulate large or heavy objects, such as lifting and throwing a payload.



Assistant Professor **João Ramos** with two of his robots. Photo by Tony Pulsone.

"I want my robots to be able to move around and interact with the world in a robust and dynamic way, to complete tasks that you are not able to do if you move around in a slow and conservative way."

Ramos hopes that someday his research can be used to create a remote avatar of a person that could be used in situations that are too dangerous or impractical to send people, such as fighting fires, handling hazardous materials, or responding to natural and man-made disasters.

Johnson named Associate Dean for Research

MechSE professor **Harley Johnson** was named Associate Dean for Research in The Grainger College of Engineering ahead of the 2019-20 academic year.

"I'm looking forward to the challenge of supporting and growing the amazing research enterprise of the college," Johnson said. "It's an exciting time for us, and I'm hopeful that my experiences as a faculty member and in the campus research administration will help me to serve The Grainger College of Engineering in this role."

The Office of the Associate Dean for Research is responsible for proactively increasing the visibility and broadening of research collaborations with state, federal, and international agencies as well as industry.

"Enhancing recognition of and growing opportunities for our exceptional research activities is vital to our mission in The Grainger College of Engineering and I have full confidence that Harley will propel us forward in these efforts," said **Rashid Bashir**, Dean of The Grainger College of Engineering.

Johnson said the size of the Grainger faculty is at an all-time high, with 460 total faculty members and about 171 of those being assistant professors.

"Not so many years ago, we were closer to 300 faculty total," he said. "So we're growing, and the assistant professor ranks are growing, and that's exciting from a research point of view. We're at the beginning of what we foresee as an era of really big research growth as all of these new faculty build their research groups and establish themselves and they start doing new and interesting things."

Stephani, Bahl each receive top U.S. award

MechSE assistant professor **Kelly Stephani** and associate professor **Gaurav Bahl** each have been awarded the highest honor given by the United States government to young professionals in science and engineering—the Presidential Early Career Award for Scientists and Engineers (PECASE).

No other university in the nation had more than one PECASE winner among mechanical engineering faculty in 2019.

The National Science and Technology Council (NSTC) established the PECASE in 1996 to recognize outstanding scientists and engineers early in their research careers. The award's winners receive a citation, a plaque, and five years of funding to help advance their research.

A number of U.S. research institutions work with the PECASE to nominate candidates. Stephani was nominated by NASA and Bahl by the Department of Defense.

Stephani's connection with NASA began in her graduate studies and has continued to grow since. She attributes much of this award to the relationship she has developed with researchers at NASA and the work they have collaborated on.

Stephani's work develops simulations of the heat loads that occur on NASA vehicles entering the Earth's atmosphere at hypersonic speeds. The process involves a period of intense loading that could determine the success or failure of the vehicle within the mission. The process lasts minutes, but there are chemical reactions and physical processes occurring over a broad range of length and time scales throughout reentry.

> "No PECASE is won by a single person. You can think of it sort of like a web—one person can only achieve so much, but if you can find new ways to connect and new ways to bring other researchers together through your work, that's really at the heart of what the PECASE is. If you cultivate those connections, the impact of your research is going to be so much greater." –Kelly Stephani

Stephani must determine what scales to consider, determine what matters to the big picture, and design her models around that. The work aims to identify what material, what material configuration, and what material thickness can successfully withstand reentry for each vehicle.

Stephani's work applies to U.S. Air Force vehicles as well and, although they share a like philosophy, they pose extremely different challenges. Air Force hypersonic vehicles undergo a similar variety of loading situations throughout their missions, but mission requirements dictate an entirely different set of capabilities and performance metrics. The difference in geometry of the typical NASA vehicle and the typical air force vehicle also introduces many unique considerations. Despite these differences, her lab develops the tools for both organizations and a variety of missions.

Bahl's research lives in the intersection between mechanical engineering, optical engineering, and electrical engineering. His projects span from micro-electro-mechanical-systems that are nanometers in size, to optical fibers that are meters long.

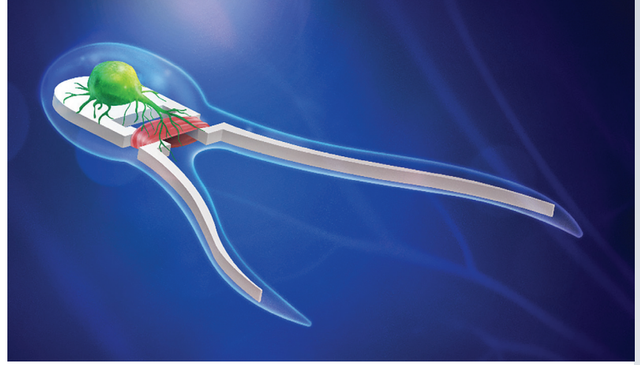
Bahl allows a series of questions to fuel his investigations, especially on systems that can operate even in the presence of defects or damage. On the subject of communication systems, Bahl asks, "Can we make a waveguide that is so resilient that wave propagation is unaffected, even if there is a defect within the waveguide material?"

Beginning in 2012, Bahl began to study Brillouin Scattering, which is a fundamental interaction between sound waves and light. The experimental devices for this series of works borrowed from principles behind whispering galleries, which were first understood by Rayleigh in St. Paul's Cathedral in London. Both St. Paul's Cathedral and Bahl's experimental devices allow sound to travel around the structure and resonate, but Bahl's devices also perform this feat for light waves. For the cathedral, this means sounds as faint as whispers can be clearly heard across the building. For Bahl, it means the miniscule interactions between light and sound can be measured experimentally.

Bahl came from an electrical engineering background, working with micro-electro-mechanical systems during his PhD. He shifted to focus on optics, fiber optics, and opto-mechanics during his post doctorate study.

Similarly, he wants the students in his group to explore different disciplines to gain a versatility that will make them better engineers. "It doesn't matter which department you're in, if you're an engineer and you're excited about the topics, just go do it."

Microscopic biohybrid robots propelled by muscles, nerves



An artist rendering of a new generation of bio-bots – soft robotic devices powered by skeletal muscle tissue stimulated by on-board motor neurons. Graphic courtesy Michael Vincent.

Researchers have developed soft robotic devices driven by neuromuscular tissue that triggers when stimulated by light—bringing mechanical engineering one step closer to developing autonomous biobots.

In 2014, research teams led by MechSE professor **Taher Saif** and bioengineering professor **Rashid Bashir** worked together to develop the first self-propelled biohybrid swimming and walking biobots powered by beating cardiac muscle cells derived from rats.

"Our first swimmer study successfully demonstrated that the bots, modeled after sperm cells, could in fact swim," Saif said. "That generation of single-tailed bots utilized cardiac tissue that beats on its own, but they could not sense the environment or make any decisions."

Led by Saif, the researchers are demonstrating a new generation of two-tailed bots powered by skeletal muscle tissue stimulated by on-board motor neurons. The neurons have optogenetic properties—upon exposure to light, the neurons will fire to actuate the muscles.

"We applied an optogenetic neuron cell culture, derived from mouse stem cells, adjacent to the muscle tissue," Saif said. "The neurons advanced towards the muscle and formed neuromuscular junctions, and the swimmer assembled on its own."

After confirming that the neuromuscular tissue was compatible with their synthetic biobot skeletons, the team worked to optimize the swimmer's abilities.

"We used computational models, led by MechSE professor **Mattia Gazzola**, to determine which physical attributes would lead to the fastest and most efficient swimming," Saif said. "For example, we looked at variations in the number of tails and tail lengths for most efficient design of the biohybrid swimmer."

"Given the fact that biological actuators, or biobots, are not as mature as other technologies, they are unable to produce large forces. This makes their movement hard to control," Gazzola said. "It is very important to carefully design the scaffold the biobots grow around and interact with to make the most out of technology and achieve locomotive functions. The computer simulations we run play a critical role in this task as we can span a number of possible designs and select only the most promising ones for testing in real life."

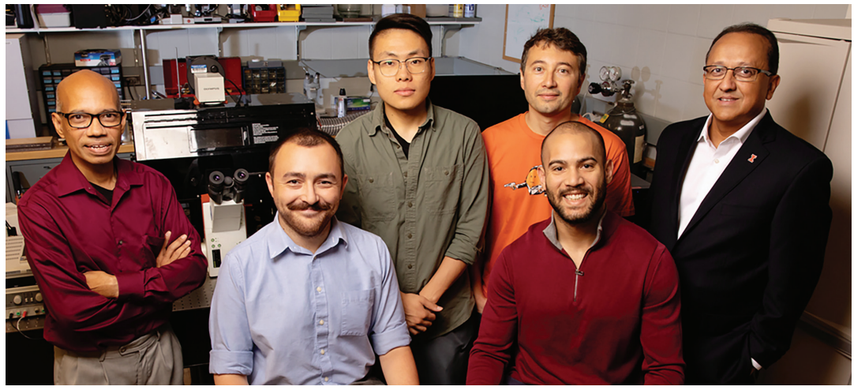
"The ability to drive muscle activity with neurons paves the way for further integration of neural units within biohybrid systems," Saif said. "Given our understanding of neural control in animals, it may be possible to move forward with biohybrid neuromuscular design by using a hierarchical organization of neural networks."

Saif and his team envision this advance leading to the development of multicellular engineered living systems with the ability to respond intelligently to environmental cues for applications in bioengineering, medicine, and self-healing materials technologies.

However, the team acknowledges that—like living organisms—no two biohybrid machines will develop to be exactly the same.

"Just like twins are not truly identical, two machines designed to perform the same function will not be the same," Saif said. "One may move faster or heal from damage differently from the other—a unique attribute of living machines."

The National Science Foundation Science and Technology Center—Emergent Behavior for Integrated Cellular Systems and NSF's Emergent Frontiers in Research and Innovation grant supported this research.



The research team includes, from left, professor **Taher Saif**, graduate student **Onur Aydin**, graduate student **Xiastian Zhang**, professor **Mattia Gazzola**, graduate student **Gelson J. Pagan-Diaz**, and professor and dean of The Grainger College of Engineering, **Rashid Bashir**.

Sinha leading research on heat generation inside cells

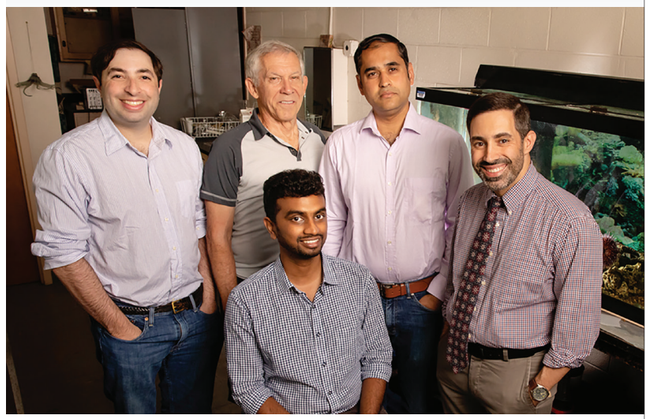
Armed with a tiny new thermometer probe that can quickly measure temperature inside of a cell, researchers have illuminated a mysterious aspect of metabolism: heat generation.

Mitochondria, the cell's power stations, release quick bursts of heat by unleashing the power stored in an internal proton "battery," the researchers found. Better understanding of this process could point to new targets for treating obesity and cancer, they say.

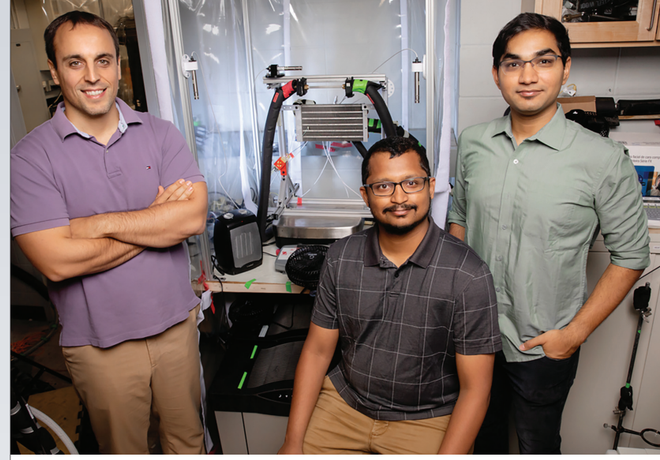
"Producing heat is part of the mitochondria's role in the center of metabolism activity," team leader and MechSE associate professor **Sanjiv Sinha** said. "It needs to produce the energy currency that's used for the activities in the cell, and heat is one of the byproducts, in most cases. But there is a mechanism that can ramp this process up to produce more heat when the body needs it. That's what fat cells do when they're in need of heat when the body's temperature goes down."

To better understand this ramping up of heat output, the researchers developed a tiny, fast-read thermometer probe to internally measure temperature inside of living cells. The mechanical design proved challenging: It had to be long enough to reach a cell under a microscope, but small enough in diameter not to harm the cell or disrupt its internal processes.

"Think about how we take temperature with a probe under our tongue. We are essentially doing the same, but inside a single cell," Sinha said. "And we wanted to be very fast to measure what's happening. Things happen inside the cell very quickly. It's like, if you're taking a young child's temperature, you need to do it very quickly, or they will move and it won't be accurate."



From left: Postdoctoral researcher **Jeffrey Brown**; Rhanor Gillette, emeritus professor of molecular and integrative physiology; **Sanjiv Sinha**, MechSE associate professor; **Daniel Llano**, professor of molecular and integrative physiology. Front row: graduate student **Manju Rajagopal**.



MechSE associate professor **Nenad Miljkovic**, left, and graduate students **Kalyan Boyina** and **Yashraj Gurumukhi**.

New technique de-ices surfaces in seconds

Airplane wings, wind turbines, and indoor heating systems all struggle under the weight and chill of ice. Defrosting and de-icing techniques are energy-intensive, however, and often require large masses of ice to melt completely in order to work. But a new technique has been developed that requires only a thin layer of ice at the interface of a surface to melt, allowing it to slide off under the force of gravity.

The method uses less than 1% of the energy and less than 0.01% of the time needed for traditional de-icing techniques.

"In order to defrost, the system cooling function is shut down, the working fluid is heated up to melt ice or frost, then it needs to be cooled down again once the surface is clean," said lead author and MechSE associate professor **Nenad Miljkovic**. "This consumes a lot of energy, when you think of the yearly operational costs of running intermittent defrosting cycles."

The researchers propose delivering a pulse of very high current to the interface between the ice and the surface to create a layer of water. To ensure the pulse is able to generate the required heat at the interface, the researchers apply a thin coating of a material called indium tin oxide—a conductive film often used for defrosting—to the surface of the material. Then, they leave the rest to gravity.

In all tests, the ice was removed with a pulse lasting less than one second. In a real-world setting, gravity would be assisted by airflow, Miljkovic said.

> "This consumes a lot of energy, when you think of the yearly operational costs of running intermittent defrosting cycles."

MechSE names first four teaching faculty

MechSE teaching faculty members (from left): **Leon Liebenberg**, **Blake Johnson**, **Bruce Flachsbart**, and **Jiajun He**.

Following a trend that is gaining speed across the U.S. and the Illinois campus, MechSE has added a new specialty-faculty designation with a focus on teaching.

Three MechSE lecturers and one new hire have been designated as the department's first "teaching faculty," with three more open slots approved to be filled. As with all Illinois faculty, they are expected to conduct research, but it could be in learning, teaching, pedagogy, or curricula, and not necessarily in a disciplinary area.

"Institutions are generally more open to having specialized faculty as part of their ranks compared to where things were 10 years ago," said Department Head **Tony Jacobi.** "Some of it is motivated by wanting to really engage students in learning activities that go far beyond where we were in the past, with active learning, and with more open-ended laboratories and design problems.

"And part of it is in wanting to meet our teaching mission in a more flexible way, perhaps a more modern way than we've done in the past—in a way that allows students to seek a learning pathway that best suits them."

MechSE's inaugural teaching faculty members are

- Teaching Assistant Professor **Bruce Flachsbart** (PhD, University of Illinois at Urbana-Champaign, 1999), who has research interests in micro-electro-mechanical system (MEMS) device design and fabrication. He joined the department in 1999.
- Teaching Assistant Professor **Jiajun He** (PhD, Stanford University, 2016), who has research interests in porous materials for clean energy applications; carbon capture; and fluid phase and interfacial behaviors associated with oil and gas production. He joined the department in 2019.
- Teaching Assistant Professor **Blake Johnson** (PhD, University of Illinois at Urbana-Champaign, 2012), who has research interests in experimental fluid mechanics, optical diagnostics, and pedagogy. He joined the department in 2014.
- Teaching Associate Professor **Leon Liebenberg** (PhD, University of Johannesburg, South Africa, 2003), who has research interests in pedagogies of engagement and emotional learning strategies; energy, materials, and the environment; and human-centered design. He joined the department in 2017.

> "These changes will strengthen our department in so many ways and help us meet our educational mission in a more efficient, engaging way. At the same time, they will leverage our research activities so that we're able to do more."

Having specialized teaching faculty will allow some tenure-system faculty to shift to more of the seminar and special-topics style courses at higher levels, leveraging their research enterprise.

"I think we're headed in the right direction," Jacobi said. "These changes will strengthen our department in so many ways and help us meet our educational mission in a more efficient, engaging way. At the same time, they will leverage our research activities so that we're able to do more.

Andrew Alleyne has received funding from the Office of Naval Research to research how making the layout of ships can help improve the ship's energy efficiency. Graduate and undergraduate students from both MechSE and ECE will be involved in running simulations for this research.

Gaurav Bahl replicated one of the most well-known electromagnetic effects in physics, the Hall effect, using radio waves (photons) instead of electric current (electrons). This technique could be used to create advanced communication systems that boost signal transmission in one direction while simultaneously absorbing signals going in the opposite direction.

Clark Bullard has been named a recipient of the National Wildlife Federation's National Conservation Special Achievement Award. Bullard is the former director of the Air Conditioning and Refrigeration Center in MechSE.

Leonardo Chamorro is part of the core team that has proposed development of an energy park on the Mexico-United States border—a concept that would replace a much-talked about border wall with infrastructure that creates energy, water, jobs, and border security to the area, on both sides of the border.

Alison Dunn recently won an Early Career Award from the Society of Tribologists and Lubrication Engineers for her research on hydrogel interfacial slip. Dunn's research focuses on characterizing the mechanics behind energy dissipation in slip at a hydrogel's surface, such as viscoelasticity and porosity.

Stefan Elbel received a best paper award at the IIR International Congress of Refrigeration as well as a best paper award at the 2019 HEFAT Conference.

Elif Ertekin has been honored with a 2019 Emerging Leader Award from the Society of Women Engineers (SWE), an honor given to individuals who have been actively engaged in an engineering or technology profession and have demonstrated outstanding leadership skills as an individual resulting in significant accomplishments. Ertekin was one of just 10 women from across the country selected to receive the competitive award.

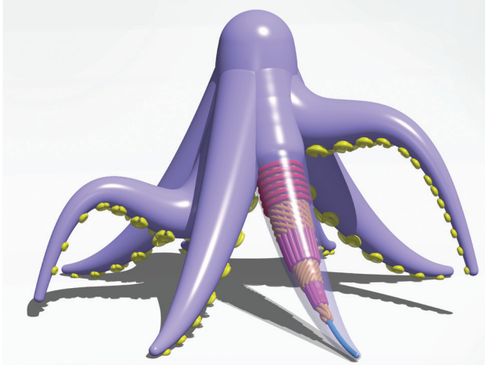
Placid Ferreira and three-time alumnus Bruno Azeredo (BSEM '10, MSTAM '14, PhDME '17) co-authored a paper published in the Proceedings of the National Academy of Sciences (PNAS) of the United States of America. The paper introduces electrochemical nanoimprinting as a new, low-cost method for large-scale production of single-crystal semiconductors, such as silicon.

Pega Hrnjak has been honored by the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) for his outstanding career achievements. He received the competitive Louise and Bill Holladay Distinguished Fellow Award for 2019, an annual award given to an ASHRAE Fellow for continuous preeminence in engineering or research work.

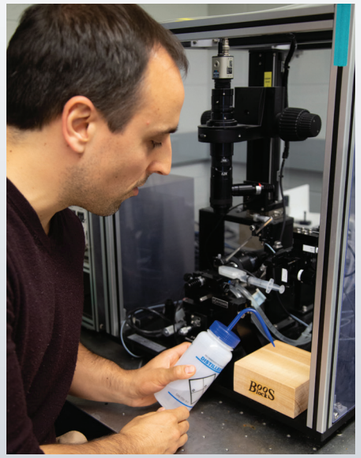
Naira Hovakimyan is part of an NSF-funded team of researchers at Illinois and Georgia Tech who are working on an advanced autopilot, which will autonomously evaluate unforeseen circumstances, take the best course of action, and land the plane safely. Similar to Captain Sully Sullenberger of the "Miracle on the Hudson," Hovakimyan said, "We want to build a flight control system that could handle a lot of uncertainties instantly."

Elizabeth Hsiao-Wecksler is advisor to a senior capstone design team receiving local accolades. Thanks to a Champaign community member reaching out, one of the Fall 2019 ME 470 projects is addressing the challenge of designing a custom walker for a local resident who has cerebral palsy.

Elif Ertekin has been named the new Director of nano-MFG, an NSF-funded nanomanufacturing node, which is the first of its kind in the U.S. "I'm very excited to lead this program to help make a lasting impact in emerging areas across nanomanufacturing," said Ertekin. "We are excited about engaging researchers from academia, labs, and industry to develop computational software tools aimed at creating smart, model-driven, and experimentally informed nano manufactured products."



Mattia Gazzola was awarded a National Science Foundation (NSF) CAREER grant for his work in viscous streaming and soft robotics. He is also part of a team that received a $7.5 million Multi-University Research Initiative (MURI) award for building a Cyberoctopus (depicted in image), a software equivalent to the marine animal that will help the team understand and leverage its ability to conduct distributed inference and decision-making, its embodied control and intelligence, and its ability to learn new behavior quickly.



Nenad Miljkovic was promoted to associate professor and received the prestigious title of Kritzer Faculty Scholar. Prior to that, he was one of six assistant professors from the College of Engineering to win the 2019 Dean's Award for Excellence in Research. He collaborated with John Boos & Co. to validate the antimicrobial efficacy of the company's proprietary cutting boards and companion board oil and cream (shown in photo). Miljkovic also demonstrated a method of achieving stable dropwise condensation of ethanol and hexane, and has developed the fundamental design principles for creating durable lubricant-infused surfaces for enhanced condensation heat transfer of low-surface-tension fluids. These findings were published in *Nano Letters*, a publication of the American Chemical Society.

Harley Johnson was interviewed by Nanowerk for his ground-breaking findings in two-dimensional materials, published recently in *ACS Nano* and *Applied Materials Today*. The next stage for Johnson's team is to explore the precise strain-rotation relationships for a variety of materials and flake sizes, so that one can use the observation for rational design of next generation microelectronic and optoelectronic devices.

Mariana Kersh educated young female athletes attending a recent basketball camp on the Illinois campus about the biomechanical applications of engineering. At the camp, four stations highlighted unique activities designed to demonstrate different concepts in mechanical science, such as electromyography.

William King's company, Fast Radius, was recently highlighted in the Economist Magazine as changing the way that physical goods are delivered. The article describes how new technologies in digital design and manufacturing allow physical goods to be made, transported, and delivered faster than ever before. Businesses are beginning to use these new technologies at scale. Fast Radius also recently announced a series B investment of $48M. The investor syndicate was led by UPS and Drive Capital.

Seid Koric, along with NCSA industry director Brendan McGinty, delivered the keynote presentation at the Industrial Day at the 2019 International Supercomputing Conference in Frankfurt, Germany. "It was all about the synergies of science and engineering with artificial intelligence (AI) and high-performance computing (HPC) in industry—needless to say a 'hot' engineering research topic," said Koric, who is also the technical assistant director of NCSA.

Amy LaViers has introduced a new point of view from which to observe robotic capabilities in her paper, "Counts of Mechanical, External Configurations Compared to Computational, Internal Configurations in Natural and Artificial Systems," published in *PLOS ONE*. She also is working in collaboration with artist-in-residence Kate Ladenheim to explore how the gendered normalisms that dominate screens and stages intersect with the diminutive status of being "cute" in the context of robotics.

Tonghun Lee is the university's academic lead for the Center for UAS Propulsion consortium. In late April, the Center hosted a program review featuring a collaboration between researchers from the Army Future Command's Army Research Laboratory, its university partners, its Department of Energy partners, and industry, who together are attempting to kick-start a way to rapidly push novel concepts into reality in UAS power and propulsion systems.

Prashant Mehta is part of a team that received a $7.5 million Multi-University Research Initiative (MURI) award for building a Cyberoctopus, a software equivalent to the marine animal that will help the team understand and leverage its ability to conduct distributed inference and decision-making, its embodied control and intelligence, and its ability to learn new behavior quickly.

Sungwoo Nam and his team have made significant strides in the field of optical strain sensors, combining graphene and colloidal photonic crystals (CPCs) to create a revolutionary new piece of technology. This work has been published as the frontispiece of the leading materials journal *Advanced Functional Materials*.

Martin Ostoja-Starzewski presented a talk, "Stochastic Partial Differential Equations Why? How? What?" in the Computational Physics Division at Los Alamos National Laboratory. The focus of his lecture was on PDEs with random field (RF) coefficients, source (forcing) term, and/or boundary/initial conditions.

James Phillips marked 50 years since he joined the Illinois faculty, having joined the Department of Theoretical and Applied Mechanics (TAM) in 1969. TAM merged with Mechanical Engineering to form the Department of Mechanical Science and Engineering (MechSE) in 2005. "Jim was the faculty who was taking care of the TAM program. He was the foundation of the TAM program," said Professor Petros Sofronis. "Jim was the person who was monitoring the progress of every graduate student in the department."

Mike Philpott and his company aPriori reached a new milestone, as award-winning multinational software company Autodesk announced aPriori as a new add-on for its Fusion 360 3D-modeling software. This is a significant milestone in CAD development, giving design engineers for the first time a design automation tool capable of automatically generating complete design solutions ready for cost-optimized mass production.

Taher Saif is collaborating with two other research groups on a new project that will receive $400,000 from the National Institutes of Health. The Exploratory/Developmental Research Grant Award (R21) will fund "In Vitro Platform for Exploring Muscle-neuron Interactions." The purpose of the project is to identify the chemicals released from muscles when they contract. Saif was also interviewed by the News-Gazette for its "Wired In" feature.

Chenhui Shao was a recipient of this year's SME Barbara M. Fossum Outstanding Young Manufacturing Engineer Award. Shao was one of 14 engineers, age 35 or younger, recognized for their exceptional contributions and accomplishments in the manufacturing industry. He was honored with the award at the North American Manufacturing Research Conference (NAMRC) in June in Erie, PA.

Sanjiv Sinha began service to the department as the new Associate Head for Undergraduate Programs. "Our department enjoys a particularly proud history of excelling in undergraduate education and mentoring students to assume leadership in engineering. I know first-hand that Illinois is the leading supplier of engineering talent to the high-tech sector, for instance. Keeping our flag flying high is an overarching goal going forward," said Sinha. He takes the reins from Elizabeth Hsiao-Wecksler, who had served in the role since August 2015.

Kyle Smith has a new research project funded by the National Science Foundation, as he continues to build on his highly praised work to develop new methods of deionizing saltwater. In his project, titled "Enabling Minimal Brine Discharge Desalination Using Intercalation Reactions," Smith will be using battery materials to overcome the limitation in the volume of waste brine that is produced during water desalination using reverse osmosis.

Sameh Tawfick was this year's recipient of the Everitt Award for Teaching Excellence, an honor that is selected by the student-led Engineering Council. Tawfick was honored for his commitment to helping students achieve their goals in and out of the classroom through innovative teaching methods, and for his continued work as an advocate for students in the classroom.

Huseyin Sehitoglu has been named the winner of the 2020 Khan International Award in the Field of Plasticity. He will be honored at the next meeting of the International Plasticity Conference—the most well-known conference in plasticity—in January 2020, in Rivera Maya, Mexico. The award recognizes "outstanding life-long contributions in the field of plasticity primarily through research contributions." Sehitoglu, who also holds the title of John, Alice and Sarah Nyquist Chair, has made important contributions to the plasticity of metals, especially on fatigue—the deterioration and failure of materials in cyclic loadings. He and his students have developed some of the most advanced theoretical models for fatigue crack initiation and fatigue crack growth accounting for the microstructure.

In Memoriam: Robert Miller

MechSE professor emeritus and alumnus **Robert Miller** passed away on Wednesday, July 24, 2019. "Bob served TAM and the University of Illinois for 40 years," MechSE department head Tony Jacobi said. "It is hard to estimate the number of students he impacted, but it is surely in the thousands. It is hard to fathom the impact he had in our community and more broadly in society." Professor Miller earned three degrees at Illinois (BSAAE '54, MSTAM '55, PhDTAM '59). He began his career in education in 1954 as a graduate teaching assistant in the former Department of Theoretical and Applied Mechanics. The following year he was promoted to instructor and taught full-time while studying for his PhD After completing his doctoral degree in 1959, he became an assistant professor. Due to his extraordinary skill in the classroom, he was promoted two years later to associate professor with tenure. He became full professor in 1968 and retired as an emeritus professor in 1994. During his 35-year career in the department, Professor Miller positively influenced hundreds of undergraduate and graduate engineering students, receiving top evaluations from them each semester. His devotion to the profession was recognized with the Everitt Award for Teaching Excellence in 1975 and the national ASEE Mechanics Division Distinguished Educator Award in 1991. His students demonstrated their appreciation by making him an Honorary Knight of St. Patrick's in 1988 and by nominating him for the Engineering College Advising Award, which he received in 1991. Professor Miller also maintained an active research program. His research, which focused on the numerical analysis of problems in solid mechanics, was widely known for producing results that engineers could put into immediate practice. All told, he produced 30 PhD and 43 Master's graduates—a level of graduate advising that exceeded departmental norms by a sizable margin.

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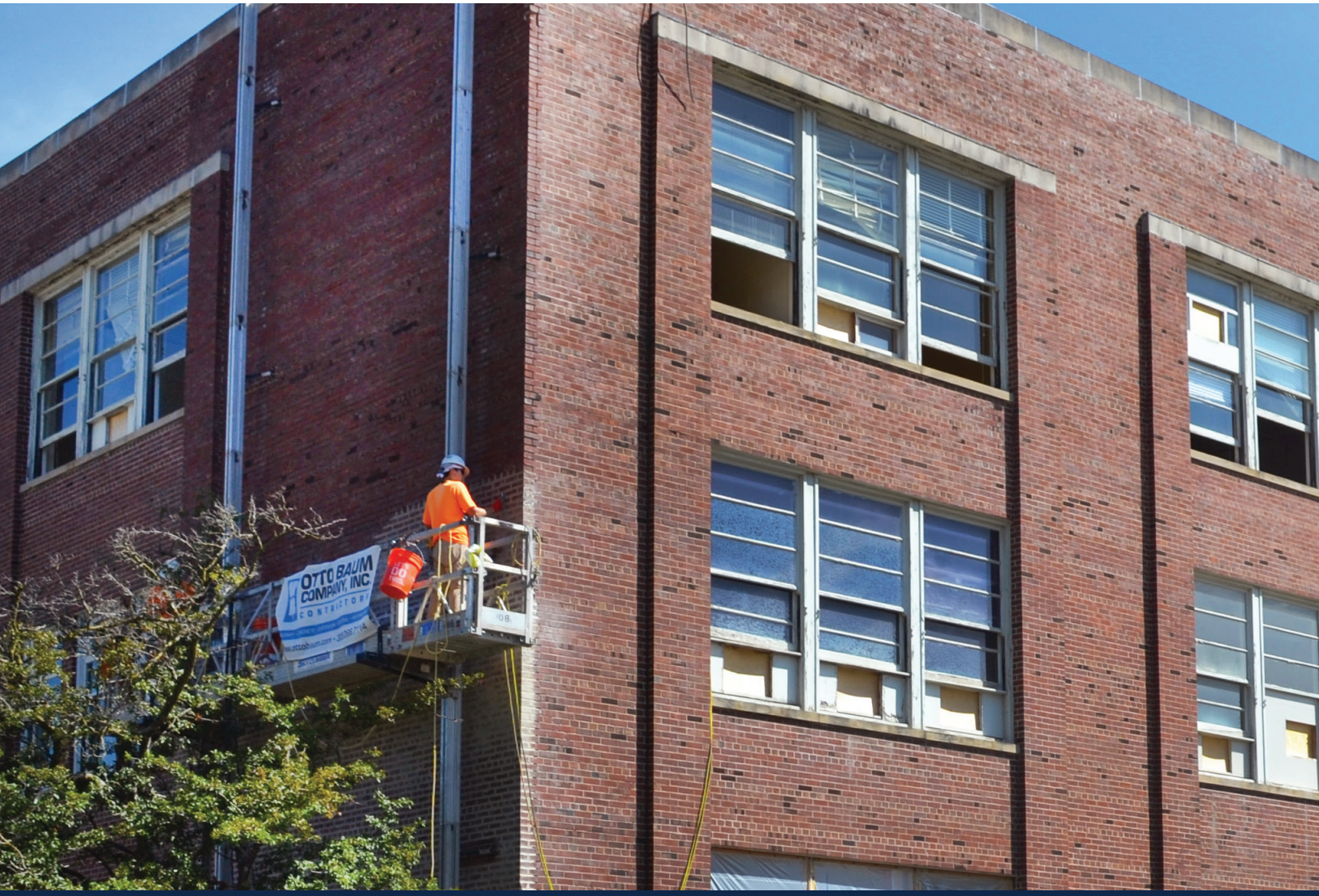

Construction is underway!

Watch the progress on MechSE's biggest project ever at mechse.illinois.edu/Lu-MEB.