College of Engineering
UNIVERSITY OF WISCONSIN–MADISON

FALL 2022 NEWSLETTER

MECHANICAL ENGINEERING

New faculty add depth in computation and data-driven engineering

Greetings!

I'm pleased to share that our department is growing considerably. This fall, we welcomed more than 300 first-year students into the department. Joining those students this year are eight new mechanical engineering faculty.

This talented group of new faculty hires significantly expands our research and educational opportunities in machine learning, data-driven design, energy systems, energy storage, batteries and robotics.

The tremendous growth in students and transformation of our department's research activities is driven by three factors. First, a UW-Madison mechanical engineering degree remains in high demand. We have more than 1,000 undergraduate students in the department, which represents a 25% increase in the last five years and ranks us as the fifth-largest major on campus. Secondly, the college is investing in research to address major challenges in sustainable energy, materials and automation, with ME faculty having a major role in those efforts.

Finally, the generous support of ME alumni and donors enables us to invest in the laboratory spaces needed for new research endeavors, and to assist our students in their educational pursuits. For example, this year alone, we will be awarding more than $500,000 in scholarships to a diverse group of undergraduate students across the department.

In addition, our outstanding faculty, staff and graduate students continue to drive significant research advances. For example, Charles Ringrose Associate Professor Lianyi Chen and PhD student Luis Izet Escano have pioneered a system for concurrently using synchrotron X-ray imaging and diffraction to fully study an important additive manufacturing technology known as electron beam powder bed fusion. Their versatile system provides the world's first window into the electron beam powder bed fusion printing process in real time, which could enable better metal 3D-printing technology and allow manufacturers to produce defect-free parts. And Bernard A. and Frances M. Weideman Professor Dan Negrut is leading a new $2.5 million National Science Foundation project to produce open source software that allows researchers to use computer simulation to design better rovers, bio-inspired robots and other autonomous agents.

Thanks for all you do to support the department. Please do stop by if your travels bring you to Madison. We would love to catch up and show you all the exciting activities that are going on in the department!

On, Wisconsin!

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Support a STAR Scholar

Effective solutions to today's challenges arise when we bring the brightest people to the table. When you make a gift to our STAR Scholarship fund, you'll help our college recruit the nation's best students so that they can become tomorrow's problem-solvers and difference-makers. Thanks to a commitment from The Grainger Foundation, there's also matching support available—meaning that you can double the impact of your support.

We need your help growing this important scholarship fund. To make a gift, contact Kyle Buchmann, senior managing director of development, at kyle.buchman@supportuw.org or (608) 630-1679.

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FOCUS ON NEW FACULTY

Ying Li harnesses supercomputers and AI to design better polymers

There's a scene in the 2010 Marvel superhero movie *Iron Man 2* that had a big impact on Ying Li.

In the movie, Tony Stark has blood poisoning from the palladium in the Arc Reactor embedded in his chest, and he races against the clock to find a benign replacement material to power the reactor. Ultimately, with the help of his AI computer system, J.A.R.V.I.S., Stark synthesizes a new element for the reactor's core—and that not only saves his life, but also increases the power in his armored suit.

"I was really excited by the concept of leveraging supercomputing power and artificial intelligence to dramatically accelerate the design of new materials, and it inspired me to explore this approach in my research," says Li, who was working on his PhD at Northwestern University when he saw the film.

Today, Li's research focuses on developing and applying multiscale and multi-physics modeling methods—combined with data science techniques such as artificial intelligence and machine learning—to understand and design advanced polymers. He joined the department as an associate professor in fall 2022.

Li's computational models and polymer research can help solve key challenges in a variety of areas, including aerospace, environmental sustainability, additive manufacturing, targeted drug delivery and clean water access.

For example, in reverse osmosis desalination, seawater is pushed through a polymer membrane at high pressure to remove minerals and contaminants and produce clean water. But, Li says, there are still unanswered questions about the fundamental mechanisms involved in the transport process through the membrane. By using his molecular simulations combined with machine learning techniques, Li aims to answer those questions and enable the design of better polymer membranes for clean water applications.

He's also involved in National Alliance for Water Innovation, Energy-Water Desalination Hub, a $110 million U.S. Department of Energy program established in 2019 to focus on early-stage research and development for energy-efficient and cost-competitive desalination technologies.

"Our modeling platform is playing a key role in this major effort, where we are working to understand how to improve polymer membranes for desalination and to reduce the energy use and cost involved," Li says. "Desalination plants use an immense amount of energy, so if we can reduce the energy cost even 1%, that would translate to millions or even billions of dollars in savings."

Li comes to UW-Madison from the University of Connecticut, where he was an assistant professor of mechanical engineering. He brings a significant research program that has garnered large grants from multiple top funding agencies, including the National Science Foundation, which awarded him its prestigious CAREER Award in 2021.

With his NSF CAREER Award project, Li is tackling the problem of plastic pollution. Specifically, he's studying biodegradable polymers to determine if they can provide the same level of mechanical performance as traditional plastics. This work involves investigating ways to tailor the macrostructure or microstructure of biodegradable polymers to achieve the desired performance for engineering applications.

Li's research is also helping to meet the needs of the aerospace industry, which extensively uses polymer composite materials in aircraft. With funding from the U.S. Air Force Office of Scientific Research, he has been developing machine learning techniques to help accelerate the design and understanding of advanced polymers for aerospace applications.

Additionally, Li's modeling platforms have improved the understanding of nanomedicines, including nanoparticles designed to deliver drugs to specific targets in the body. He has pioneered methods to model the movement of nanomedicines as they flow through the human vascular system and interact with structures within the body—research that could enable new forms of nanoparticles that are more efficient and have better drug-loading capacity for potential cancer therapies.

Li received his bachelor's degree from Zhengzhou University, China, and his master's degree from Tsinghua University, China, both in engineering mechanics. After earning his PhD in mechanical engineering from Northwestern University in 2015, he joined the faculty at the University of Connecticut.

As he starts his new position at UW-Madison, Li is excited about many opportunities for collaboration.

"The department is very strong in the area of computation and data-driven engineering, which is my primary area," he says. "Also, the department and college have many outstanding faculty working in areas such as advanced manufacturing and polymer design, and I envision my group serving as a bridge that connects different labs, forming new interdisciplinary collaborations to solve big challenges."

FOCUS ON NEW FACULTY

Allison Mahvi, enabling new energy storage systems

When we think of energy storage, batteries typically come to mind. But Allison Mahvi envisions something bigger: the buildings in which we live and work.

"Buildings can be a good way to store energy," says Mahvi, who joined the department as an assistant professor in fall 2022. "A lot of the energy that buildings consume is used for heating and cooling purposes. So, integrating thermal storage into buildings can give us this really big, flexible storage resource that is built into the supply side of the electric grid."

Mahvi's research focuses on characterizing thermal energy storage materials and integrating them into building energy systems. She has extensive experience in experimentally and computationally evaluating novel heat transfer components for these systems. Ultimately, her goal is to help increase the amount of renewable energy sources that are incorporated into the grid.

New storage solutions would allow intermittent energy sources such as solar to generate a much larger fraction of our electricity. For example, in a residential home that uses solar power, the HVAC system could freeze water when the sun is shining brightly. Then, when people return to their homes in the evening the system could discharge the energy stored in the ice to cool down their home.

"The idea is to develop ways to store a bunch of cooling or heating while you have extra renewable power generation, so your generation and use don't need to be aligned," Mahvi says. "And, compared to batteries, the lifetime should be a lot better with thermal storage systems. You can freeze water over and over again, and it doesn't degrade the ice."

In her research, Mahvi has investigated different phase change materials that transition at a higher temperature than ice. These materials could enable more efficient thermal storage systems that integrate seamlessly with HVAC equipment that many people already use.

Mahvi completed her PhD in mechanical engineering at Georgia Institute of Technology in 2018 and earned her bachelor's degree in mechanical engineering from UW-Madison in 2012. Previously, she was a postdoctoral researcher at the National Renewable Energy Laboratory.

Read more: go.wisc.edu/mahvi-fall22

FOCUS ON NEW FACULTY

Eric Kazyak, investigating interfaces to enable improved batteries

For society to transition from fossil fuels to renewable, but intermittent, energy sources such as wind and solar, there is a pressing need for new energy storage technologies that can keep the power on when the sun isn't shining or the wind fades.

While current storage technologies such as lithium ion batteries are highly useful for powering electric vehicles and other electronics, they have downsides. For one, the process of mining critical materials to make these batteries significantly damages the environment. In addition, the price of lithium has been steadily increasing, largely due to the growing demand for electric vehicles, and this is among the factors driving up prices for those vehicles.

"We need other options for energy storage that can be scaled up to the massive scale necessary for things like electric vehicles and grid-scale storage, without causing extreme harm to the environment, and at a relatively modest cost, so that it's widely accessible," says Eric Kazyak, who joined the department as an assistant professor in fall 2022.

Kazyak, who focuses on understanding the interfaces between materials in energy storage systems, hopes his research will lead to next-generation batteries that are less costly and more sustainable.

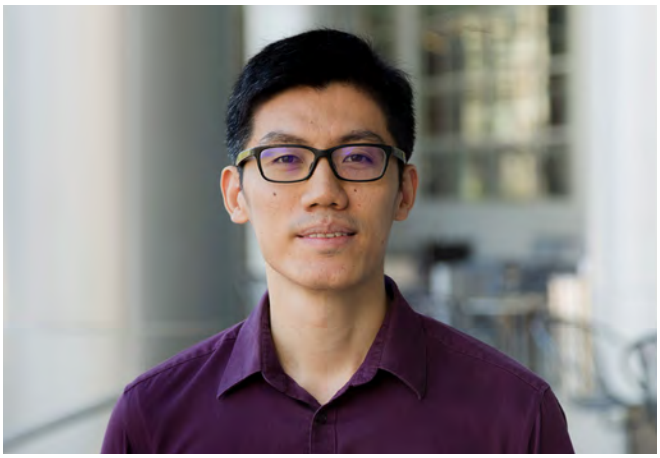
"The performance and stability of a battery is affected by the interfaces between different materials," he says. "My expertise is in understanding why those interfaces and materials behave the way they do, and then using that understanding to rationally design interfaces for improved battery performance."

Kazyak earned his master's degree and PhD in mechanical engineering from the University of Michigan and was a postdoctoral fellow at Michigan prior to joining UW-Madison.

One main thrust of his research is investigating so-called "beyond lithium" batteries, such as sodium ion batteries or sodium metal batteries.

Since sodium is far more abundant on earth than lithium, batteries that use sodium could be much less expensive for applications in electric vehicles and grid storage. In his research, Kazyak is working to overcome various challenges posed by sodium-based batteries to enable this technology.

Read more: go.wisc.edu/kazyak-fall22



FOCUS ON NEW FACULTY:

Jinlong Wu, leveraging data-driven modeling to predict the future of complex systems

When we look at a cloud, there are many ways we might describe it: wispy, fluffy, dense, dark or ominous.

When Jinlong Wu looks at a cloud, however, he sees a complex dynamical system that presents an important, yet vexing, modeling challenge. "Modeling and simulating them is critical to predicting future climate—but it turns out to be much more complicated than they look like," says Wu, whose research focus is mainly on modeling and simulating such complex systems. "They consist of different types of physics at different scales—for example, condensation of water vapor, collision of cloud droplets, and convection at large scale. One current challenge of simulating complex dynamical systems like clouds is that existing models are often not good enough."

Wu, who joined the department in August 2022 as an assistant professor, says that advances in machine learning make it possible to improve those models by leveraging different types of data. Yet, he says, their predictive capabilities are still lagging, and that's also one reason for challenges in building digital twins (virtual counterparts of real objects or systems) to simulate real-world engineering applications.

Wu aims to change that. Through his research, he plans to develop predictive data-driven modeling techniques to simulate complex dynamical systems and build reliable digital twins for applications in areas that include energy harvesting, advanced manufacturing, and robotics.

As an undergraduate, Wu channeled his curiosity about energy harvesting into a thermal energy and power engineering bachelor's degree from Southeast University in China, where he also earned his master's degree in power engineering. He received his PhD in aerospace engineering from Virginia Tech and then pursued postdoctoral research in large-scale fluid dynamics—motivated, in part, by damage to the global climate caused by excessive fossil energy use over the past century.

Now, as he begins his faculty career, Wu says he sees the future of his research as an interdisciplinary program that bridges methodology development in applied math and statistics along with the need for modeling complex dynamical systems in engineering applications.

Read more: go.wisc.edu/wu-fall22

Two students land NSF Graduate Research Fellowships

Joshua Gasick

Aaron Young

PhD student Joshua Gasick and alum Aaron Young (BSME '22) have received prestigious National Science Foundation Graduate Research Fellowships in 2022.

Gasick (BSME '20) is a member of Elmer and Janet Kaiser Professor Xiaoping Qian's Computational Design and Manufacturing Lab, and his research focuses on numerical optimization. He is working with Qian on topology optimization for additive manufacturing that includes a manufacturability constraint in the optimization. Gasick is also working on research projects related to physics-informed neural networks and how they can be used in conjunction with isogeometric analysis or parametrized curves and surfaces.

Young's research interests relate primarily to autonomous vehicles and autonomous robots. In particular, he's interested in using simulation to inform the development of algorithms to be used for autonomous agents.

He worked as an undergraduate researcher in the Simulation Based Engineering Laboratory (SBEL) for three years under Bernard A. and Frances M. Weideman Professor Dan Negrut. Young's main contributions to the lab revolved around the autonomous vehicle thrust, where researchers use a simulation engine called Project Chrono to simulate autonomous convoys, experiment with human-autonomous vehicle interactions, and develop an autonomous scale vehicle.

Young also led the Wisconsin Autonomous student organization for three years. "Much of the work I have done in Wisconsin Autonomous is directly applicable to SBEL, and vice-versa," he says. "Augmenting my classroom experiences with extracurriculars such as Wisconsin Autonomous and SBEL was imperative to my success in acquiring internships and receiving the NSF Graduate Research Fellowship."

In fall 2022, Young is beginning his PhD studies in mechanical engineering at MIT, where he plans to continue working on research in the autonomy realm. Looking back on his undergraduate experience at UW-Madison, he is especially grateful for the remarkable mentoring and support her received in the department.

"The most important component to my success as an undergrad was working with Professor Negrut and ME PhD student Asher Elmquist," Young says. "They invested a lot of time and effort into me, and I hope to pay that forward to my future colleagues. Their impact on me and my future is immeasurable."

The NSF fellowship recognizes and supports outstanding graduate students in STEM fields. Fellows receive three years of financial support through a $37,000 annual stipend and a $12,000 education allowance.

Engineer reinvents himself as an ambassador to excite kids worldwide about science

When Jay Flores (BSME '12) isn't climbing and leaping through obstacle courses to train for NBC's *American Ninja Warrior* or traveling internationally to deliver energizing keynotes, he spends a lot of time in his kitchen cooking up fun, interactive science experiments to teach kids about STEM.

He's also a member of the Mystery Science Team through Discovery Education, a digital learning platform that reaches K-12 students in tens of thousands of classrooms across the United States. More than a million students see Flores in Mystery Science videos, where he fosters curiosity by answering questions like "Why don't people fall out of roller coasters when they go upside down?"

Inspiring youth to excel in STEM and become tomorrow's innovators isn't just a day job for Flores. Rather, he wears his STEM ambassador hat pretty much 24/7.

"I focus on leading with the passion behind STEM, finding the real-life examples that excite kids and then showcasing the science and math behind it," Flores says. "By nurturing kids' sense of wonder, I hope to inspire them to explore STEM and go on to use their knowledge to do cool things and make a positive impact in the world."

A Milwaukee native, Flores attended UW-Madison on a full scholarship as a Rockwell Scholar. During his time as an engineering undergraduate, he became interested in STEM outreach through his involvement in extracurricular activities and student organizations.

In particular, he says membership in the UW-Madison chapter of the Society of Hispanic Professional Engineers (SHPE) allowed him to grow as a leader and develop his presentation skills as he participated in the group's K-12 STEM outreach efforts.

After graduating with his bachelor's degree, along with certificates (minors) in international engineering and in leadership, Flores started his career at Rockwell in the company's global sales training program. He then advanced into a sales position based in south Florida.

Meanwhile, he continued to pursue his passion for outreach, bringing his inspiring, inclusive message about the power of STEM (as well as his characteristic high enthusiasm) to after-school programs and events. In 2014, he gave a well received TEDx talk, "Growing with S.T.E.M.," targeted at youth.

Then one day, everything changed. Flores was staffing Rockwell's booth at the FIRST Robotics World Championship, and he struck up a conversation with a Rockwell vice president who happened to have seen the TEDx talk. "She said, 'You're like our STEM ambassador,'" Flores recalls. "And it occurred to us both that this kind of role could be good for the company and the industry overall by helping to strengthen and diversify the STEM workforce pipeline for the future."

That conversation set into motion a new Rockwell position—global STEM ambassador—a job specifically designed for Flores that would leverage his unique skills and passion. In his new role, Flores focused on developing the global strategy for Rockwell's investments in STEM outreach to ensure that the company's efforts were impactful and helping to increase diversity in technical fields. He also traveled to many countries to lead STEM events.

Then, in early 2020, everything changed again. The COVID-19 pandemic put an end to international travel and large in-person gatherings. With all of his upcoming STEM events canceled, Flores had to adapt.

He realized there was an opportunity to support youth who were now attending school remotely and might lack access to enriching STEM activities. He tapped the one resource most students could access: a kitchen. There, within his own kitchen, Flores created a STEM education series called *It's Not Magic, It's Science!* The series consists of science experiments disguised as magic tricks to increase excitement and awareness in STEM. He created short, entertaining videos for each "magic trick," which he posted on TikTok and other social media platforms. (His handle is @JayFloresInspires).

It's Not Magic, It's Science! took off on social media, eventually racking up millions of views. At the same time, Flores felt he was ready to take on another creative challenge: expanding his impact by working with a wider variety of STEM-focused organizations. He decided to leave his job at Rockwell and, in January 2021, he formed Invent The Change, a company with a mission to change the world by inspiring young minds to keep doing cool things in STEM.

In 2022, Flores fulfilled a longtime dream: After 10 years of rejected applications and failed walk-on attempts in multiple cities, he finally got the call to compete on the NBC show *American Ninja Warrior*. As a rookie, he made it to the semifinals in Los Angeles, where he used the opportunity to share his message about STEM and perseverance.

Read more: go.wisc.edu/flores22

Above: Jay Flores delivers a live performance of *It's Not Magic, It's Science!* at the Invention Convention U.S. Nationals in June 2022. Submitted photo. *Below:* Jay Flores competes in the *American Ninja Warrior* 2022 semifinals. Submitted photos.

The exterior of the team's house design. Submitted photo.

The UW-Madison team members, from left: Klare Hollenkamp, Kari Weiss, Morgan Kunz, Evan Fernandez, Kirk Mendoza, Sammie Lundin and Forrest Ahrens.

Team from UW-Madison and UW-Milwaukee places second in 2022 Solar Decathlon

A team of students from the UW-Madison and UW-Milwaukee placed second in the new housing category in the 2022 Solar Decathlon design challenge, held April 22-24 in Golden, Colorado.

The U.S. Department of Energy sponsors the annual Race to Zero Solar Decathlon for colleges and universities each year, where students compete to use the latest technologies to design and build the most sustainable buildings possible.

This is the seventh year in a row that UW-Madison's College of Engineering and UW-Milwaukee's School of Architecture and Urban Planning have teamed up to design a house for the competition.

The UW-Madison team was made up of seven ME majors: Sammie Lundin, Klare Hollenkamp, Kari Weiss, Morgan Kunz, Evan Fernandez, Kirk Mendoza and Forrest Ahrens.

"It was extremely rewarding to see all our hard work these past two semesters be recognized on the national level," says Lundin, co-team leader for UW-Madison. "Everyone on the UW-Madison team was integral to the success of our project and we are all so proud of the final product and the outcome. I would recommend this project to upcoming mechanical engineering students about to take their senior design class."

While the contest does generate ideas about energy efficiency, the designs are also created for specific clients—in 2022, for a couple who want to build a home in Egg Harbor, Wisconsin. The students created the two-story house so it could be mass produced, and used a modular design to provide flexibility for the layout.

The student team members from UW-Milwaukee provided energy-saving design features while the UW-Madison engineering students developed the mechanical systems that support that goal.

"Being on the team and participating in the Solar Decathlon gave me valuable hands-on experience in working with other industry professionals and students of different majors," Lundin says. "It also taught me to be creative in solving real-world problems and that each decision we made had a tradeoff that we had to evaluate and consider. We got to apply what we learned in class at a much deeper level and on a real-world application. This experience has inspired me and a few other team members to want to design their own net-zero homes in the future. This whole experience, which included applied solar technologies, has solidified my decision to pursue a graduate degree in solar from UW-Madison."

PhD student earns 2022 APS research recognition

Qilin Guo

PhD student Qilin Guo received the 2022 Rosalind Franklin Young Investigator Award.

This biannual award is given by the Advanced Photon Source (APS) user organization. It recognizes important scientific or technical accomplishments at (or beneficial to) the APS by a young investigator, typically a senior graduate student or early career researcher.

Guo's research revealed process dynamics in three major aspects of the laser powder bed fusion additive manufacturing process. His PhD advisor, Charles Ringrose Associate Professor Lianyi Chen, nominated him for the award, and calls Guo one of the pioneers of using synchrotron-based in situ X-ray imaging and diffraction to study the physical dynamics of metal additive manufacturing process.

Guo's findings related to powder spattering, melt pool evolution, melt flow evolution and solidification dynamics have the potential to transform the metal additive manufacturing industry. His work may help manufacturers design better machines and help part manufacturers make higher quality parts. It may also help feedstock material producers design and develop better metal powders and help reduce the level of effort required for qualification of components.

"I feel truly honored to receive this award," Guo says. "The APS has been my other academic home during my entire PhD study. My achievements greatly benefit from the excellent researchers and the world-class facilities there. Having my work recognized in this way is really a proud moment for me and my entire team."

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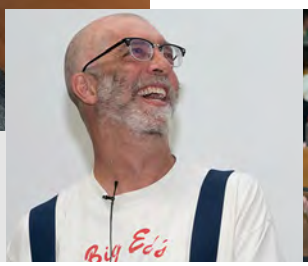

Above: Kris Dressler receives a standing ovation at Dresslerfest. *Right:* Kris Dressler at the podium at Dresslerfest. *Far right:* Kris Dressler kept faculty and students entertained at the event. All photos submitted.

Kris Dressler rocks Dresslerfest

After Kris Dressler was diagnosed with an aggressive form of brain cancer called glioblastoma in fall 2021, the department hosted a special lecture featuring the popular assistant teaching professor. At "Dresslerfest" in April 2022, he shared insights and observations from his re-evaluation of life with the engineering students, staff, faculty and alumni who attended. At the event, John Bollinger Chair of Mechanical Engineering and Bernard A. and Frances M. Weideman Professor Darryl Thelen also announced the new Kris Dressler STAR Scholarship. The "Strategic Targeted Achievement Recognition" Scholarship will help recruit and retain the most talented incoming engineering students. The Grainger Foundation is matching gifts to the scholarship fund.

To contribute to the Kris Dressler STAR Scholarship, go to:
supportuw.org/giveto/dresslerscholars

Watch a recording of the Dresslerfest lecture:
go.wisc.edu/dresslerfest