College of Engineering
UNIVERSITY OF WISCONSIN–MADISON

FALL 2025 NEWSLETTER

DEPARTMENT OF

MECHANICAL ENGINEERING

Devesh Ranjan, Grainger Dean of the College of Engineering, with Professor Riccardo Bonazza at the ME 903: Distinguished Alumni Seminar Series kickoff, where Ranjan delivered a lecture to celebrate our department's 150th anniversary. Photo: Todd Brown.

Greetings! As fall settles in across campus, we are once again welcoming a record-breaking class of first-year students. Enrollment in our mechanical engineering and engineering mechanics programs now exceeds 1,700 students, an increase of more than 10% from last year. This continued growth is a welcome challenge that inspires us to keep innovating in how we teach, mentor and support the next generation of Badger engineers.

This year marks a very special milestone: the 150th anniversary of mechanical engineering at UW-Madison. William J.L. Nicodemus was appointed the first professor of mechanical engineering in 1875, expanding his duties beyond leading military drills and teaching civil engineering. That appointment launched a tradition of innovation in mechanics and mechanical engineering at UW-Madison that continues to this day. To celebrate, we are hosting a series of alumni seminar speakers throughout the academic year and unveiling a new history wall in the ME Building that honors our legacy while showcasing the research and student activities that keep the department vibrant and forward-looking. Professor Emeritus Tim Osswald will deliver a special lecture on the department's history at our annual alumni luncheon on Nov. 7. I hope you will join us for this opportunity to reflect on our heritage and celebrate the contributions of generations of Badger engineers.

Even as we celebrate our past, we are investing in the future. A major step forward is the planning of a standalone aerospace engineering degree program, which we intend to launch in fall 2026. This will be the first aerospace engineering program in Wisconsin and comes in direct response to student interest and industry demand. The program will build on our strengths in mechanics and mechanical engineering while preparing graduates for careers in aviation, space exploration and the next generation of aerospace technologies. To lay the foundation, we are hiring new faculty and investing in facilities such as a flight simulator and an instructional wind tunnel for hands-on learning. These investments will ensure our students are well prepared for careers that support Wisconsin's economic growth and contribute to national leadership in aerospace innovation.

We are also strengthening our graduate programs. This fall we launched a first-year graduate fellowship program designed to recruit and onboard new PhD students. In this program, we partner with faculty to recruit promising and motivated students, with the department providing resources in the first semester to help them transition into graduate school and begin their research. It is a true win-win: Faculty gain talented new colleagues in their labs, and students receive the foundation they need to thrive from the outset. Most importantly, these fellowships are made possible by the generosity of our alumni. We are deeply grateful for this support, which enables us to both advance research and enrich undergraduate education through the teaching, mentorship and guidance our graduate students provide in hands-on laboratories.

Thank you for being part of our community during this landmark year. I look forward to celebrating 150 years of mechanical engineering with you and to a bright future ahead. **On, Wisconsin!**

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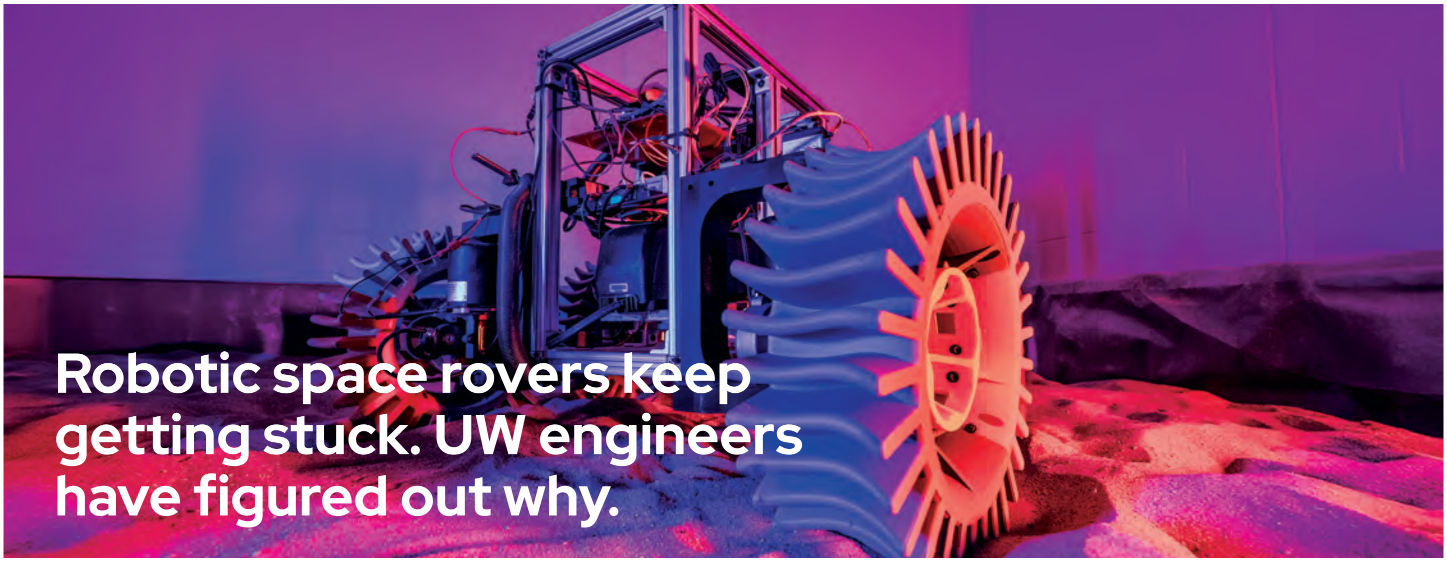
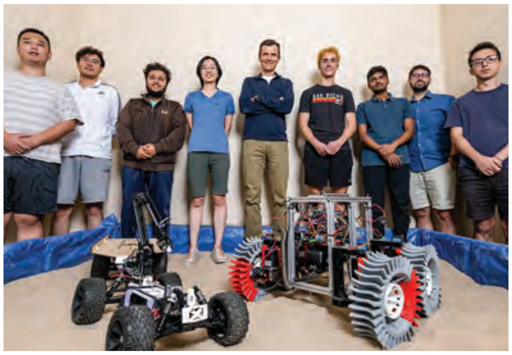


Robotic space rovers keep getting stuck. UW engineers have figured out why.

When a multimillion-dollar extraterrestrial vehicle gets stuck in soft sand or gravel—as did the Mars rover Spirit in 2009—Earth-based engineers take over like a virtual tow truck, issuing a series of commands that move its wheels or reverse its course in a delicate, time-consuming effort to free it and continue its exploratory mission.

While Spirit remained permanently stuck, in the future, better terrain testing right here on terra firma could help avert these celestial crises.

Using computer simulations, Bernard A. and Frances M. Weideman Professor Dan Negrut and his collaborators have uncovered a flaw in how rovers are tested on Earth. That error leads to overly optimistic conclusions about how rovers will behave once they're deployed on extraterrestrial missions.



Professor Dan Negrut with his team. Photos: Joel Hallberg.

An important element in preparing for these missions is an accurate understanding of how a rover will traverse extraterrestrial surfaces in low gravity to prevent it from getting stuck in soft terrain or rocky areas.

On the moon, the gravitational pull is six times weaker than on Earth. For decades, researchers testing rovers have accounted for that difference in gravity by creating a prototype that is a sixth of the mass of the actual rover. They test these lightweight rovers in deserts, observing how they move across sand to gain insights into how they would perform on the moon.

It turns out, however, that this standard testing approach overlooked a seemingly inconsequential detail: the pull of Earth's gravity on the desert sand.

Through simulation, Negrut determined that Earth's gravity pulls down on sand much more strongly than the gravity on Mars or the moon does. On Earth, sand is more rigid and supportive—reducing the likelihood it will shift under a vehicle's wheels. But the moon's surface is "fluffier" and therefore shifts more easily—meaning rovers have less traction, which can hinder their mobility.

"In retrospect, the idea is simple: We need to consider not only the gravitational pull on the rover but also the effect of gravity on the sand to get a better picture of how the rover will perform on the moon," Negrut says. "Our findings underscore the value of using physics-based simulation to analyze rover mobility on granular soil."

The team detailed its findings in a paper published May 27, 2025, in the *Journal of Field Robotics*.

The researchers' discovery resulted from their work on a NASA-funded project to simulate the VIPER rover, which had been planned for a lunar mission. The team leveraged Project Chrono, an open-source physics simulation engine developed at UW-Madison in collaboration with scientists from Italy. This software allows researchers to quickly and accurately model complex mechanical systems—like full-size rovers operating on "squishy" sand or soil surfaces.

While simulating the VIPER rover, they noticed discrepancies between the Earth-based test results and their simulations of the rover's mobility on the moon. Digging deeper with Chrono simulations revealed the testing flaw.

The benefits of this research also extend well beyond NASA and space travel. For applications on Earth, Chrono has been used by hundreds of organizations to better understand complex mechanical systems—from precision mechanical watches to U.S. Army trucks and tanks operating in off-road conditions.

"It's rewarding that our research is highly relevant in helping to solve many real-world engineering challenges," Negrut says. "I'm proud of what we've accomplished. It's very difficult as a university lab to put out industrial-strength software that is used by NASA."

FOCUS ON NEW FACULTY

Harsh Sharma is leveraging AI to create better digital twins

Digital twins—virtual representations of real-world objects or systems such as a jet engine or power plant—are powerful computational tools for enabling engineers to better design, analyze, control and optimize complex systems.

Unlike traditional modeling and simulation approaches, there is a back-and-forth interplay between a physical system and its digital twin. "So, the data collected from the physical system is used to improve the computational models in the digital twin. Then, based on that data, the digital twin informs the analysis, control and perhaps maintenance of the real-world system," says Harsh Sharma, who joined the department as an assistant professor in August 2025.

Sharma's research is focused on integrating underlying scientific principles and domain-specific knowledge with machine learning/AI techniques for design, analysis and control of complex and large-scale dynamical systems, with an emphasis on digital twins. In particular, he's working to enable digital twins that are predictive and computationally efficient.

In other words, they're more accurate and reliable.

"Essentially, I'm trying to embed the underlying physics of the problem into the design of the algorithm itself, which allows me to develop a data-driven model that respects physical laws and has predictive capability," he says. "So, when the model is operating and encounters a situation that it might not have seen in the training data, it can still extrapolate to correctly handle that new problem."

In his research, Sharma works on a wide variety of computational methods, ranging from traditional modeling and simulation approaches to recent developments in data-driven modeling and scientific machine learning techniques. His research has potential applications in diverse areas, including soft robotics, structural dynamics, astrodynamics and computational physics.

Sharma comes to UW-Madison from the University of California, San Diego, where he was a postdoctoral research scholar in the Department of Mechanical and Aerospace Engineering. He received a dual degree (BS and MS) in mechanical engineering from the Indian Institute of Technology-Bombay and a master's degree in mathematics from Virginia Tech. Sharma earned his PhD in aerospace engineering from Virginia Tech in 2020.

Moldable, flexible sensor is a versatile option for detecting irregularities in everything from manufacturing to mobility

After setting out to create a flexible sensor that could aid his advisors' examination of the mechanical forces behind traumatic brain injury, PhD student Sinan Candan hit a roadblock.

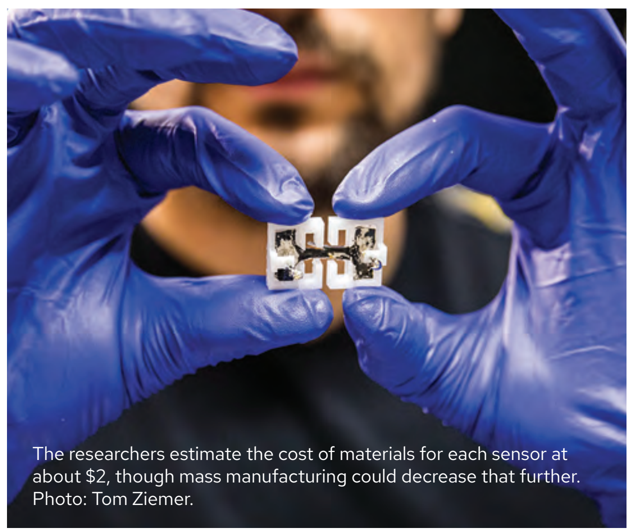
While economical and useful, the sensor he'd developed wasn't the right fit: It couldn't provide the granular level of sensitivity and precision for characterizing brain material.

Candan showed his sensor's data to his advisors, Bjorn Borgen Professor Christian Franck and Harvey D. Spangler Associate Professor Jacob Notbohm. And the three researchers observed that, while the sensor might not be capable of tracking impacts on brain material, it was still effective for detecting periodic forces—the sort that might be relevant in structural health monitoring, underwater robotics or human health screening.

"We diverted a bit and found a really interesting set of applications," says Candan (MSBME '23), who came to UW-Madison from Turkey as a Fulbright Scholar.

The sensor could help detect irregularities in manufacturing equipment, report biomechanical data about a user's walking gait, or even monitor vocal vibrations of someone recovering from an injury.

With guidance from Alfred Fritz Assistant Professor Joseph Andrews and his PhD student Vanessa Barton, Candan used a mixture of polydimethylsiloxane (a silicone polymer), carbon nanotubes and graphene to create the flexible and moldable sensor, which the researchers can punch out into different shapes.



The researchers estimate the cost of materials for each sensor at about $2, though mass manufacturing could decrease that further. Photo: Tom Ziemer.

The method expands upon previous work by South Korean researchers, while demonstrating the ability to detect periodic, vibratory deformations and mechanical loads on a variety of surfaces, even when submerged underwater. Associate Professor Melih Eriten's group, including PhD student Haocheng Yang, confirmed the sensor's performance in measuring vibrations.

Professor Xiaoping Qian holds the team's innovative heat exchanger, which has twisty internal fluid channels. Photo: Joel Hallberg.

Tapping a new toolbox, engineers buck tradition in new high-performing heat exchanger

By combining topology optimization and additive manufacturing, a team of UW-Madison engineers created a twisty high-temperature heat exchanger that outperformed a traditional straight channel design in heat transfer, power density and effectiveness.

And they used an innovative technique to 3D print—and test—the metal proof of concept.

High-temperature heat exchangers are essential components in many technologies for dissipating heat, with applications in aerospace, power generation, industrial processes and aviation.

"Traditionally, heat exchangers flow hot fluid and cold fluid through straight pipes, mainly because straight pipes are easy to manufacture," says Xiaoping Qian, Elmer R. and Janet Ambach Kaiser Professor. "But straight pipes are not necessarily the best geometry for transferring heat between hot and cold fluids."

Additive manufacturing enables researchers to create structures with complex geometries that can yield more efficient heat exchangers. Given this design freedom, Qian set out to discover a design for the hot and cold fluid channels inside a heat exchanger that would maximize heat transfer.

He harnessed his expertise in topology optimization, a computational design approach used to study the distribution of materials in a structure to achieve certain design goals. He also incorporated a patented technique, called projected undercut perimeter, that considers manufacturability constraints for the overall design.

With an optimized design in hand, Qian worked with MS&E Professor Dan Thoma, who led the 3D printing of the heat exchanger using a metal additive manufacturing technique called laser powder bed fusion.

Thermal-hydraulic tests showed the optimized design was not only more effective in transferring heat, but also achieved a 27% higher power density than a traditional heat exchanger. That higher power density enables a heat exchanger to be lighter and more compact—useful attributes for aerospace and aviation applications.

New design framework makes it easier to create custom shock-absorbing materials

UW-Madison engineers have developed a comprehensive framework that accelerates improvements to shock-absorbing foam materials.

The materials have an array of uses ranging from sports or military helmet liners to struts that cushion a spacecraft landing.

"We've developed a novel design framework to help designers create a shock-absorbing material of a specific geometry that does exactly what they want it to do without adding weight or extra volume," says Ramathasan Thevamaran, Bernard A. and Frances M. Weideman Associate Professor, who led the research. "It allows designers to customize the material for the best performance, tailored to diverse applications, without going through lots of experimental trial and error."

The advance also opens a new perspective on how to approach the design of protective materials by challenging conventional wisdom.

Traditionally, the goal has been to design a shock-absorbing material with mechanical properties that allow it to maintain a constant stress plateau. Designers typically use an iterative process that focuses on optimizing the mechanical properties without factoring in the thickness and area of the foam pad used in applications.

The UW-Madison researchers took a different approach. They investigated the thickness and area of foam pads in conjunction with mechanical properties. To their surprise, they discovered that, in certain impact scenarios, foams exhibiting a different kind of behavior—a nonlinear stress-strain response—can outperform foams that hold the stress level constant.

The team detailed its findings in a paper published August 4, 2025, in the journal *Nature Communications*.

For their final project, students worked in teams to create educational board games that covered concepts learned in the course. Submitted photo.

In new engineering course, sustainability policy is debatable and alternative views are abundant

A new course in the department will enable engineers to make a greater real-world impact by equipping them to navigate complex problems that don't have clear solutions and are highly interconnected and interdisciplinary.

"The long-term trajectory of different technologies is often driven by or connected with policy and economics, so being able to understand the broader context is a valuable skill for engineers who want to make a difference in benefitting society, whether they are working in industry or in academia," says Assistant Professor Eric Kazyak.

That's why Kazyak created a new course, *Engineering Sustainability: Linking Technology, Policy, Health and Economics,* which is open to undergraduates and graduate students. In the course, students develop a variety of versatile skills, including communication and learning how to critically assess technologies based on a mix of real-world factors such as policy, regulations, economics and health impacts.

For one assignment, students leveled up their communication and policy chops through an engaging debate exercise. Kazyak divided the students into technology-themed teams—alternative liquid fuels, hydrogen and battery electric vehicle. On each team, students took on different roles: technology expert, health expert, policy expert and an opposition researcher.

Each team delivered a 10-minute presentation to a panel of leaders of a fictional country, attempting to persuade them to invest in the team's technology as the best solution for meeting the majority of the country's energy needs. The teams then had five minutes to ask questions and form rebuttals to the other teams, followed by a second round of arguments. At the conclusion, Kazyak led the class in a discussion about how this exercise could be applicable to real-world scenarios.

"There were students who did a complete 180-degree turn on certain technologies, who said, 'I thought this technology shouldn't even be in the discussion, but I see now that, in certain cases, it makes a lot of sense.' It was a really informative activity," Kazyak says.

Faculty news

Lih-Sheng (Tom) Turng, Consolidated Papers Foundation Professor sponsored by the Mead Witter Foundation, was elected fellow of the Royal Society of Chemistry, a prestigious honor that recognizes his exceptional contributions to the chemical sciences. Turng conducts transformative research across a wide range of polymer processing and biomedical areas. He is the most published faculty member in the department, with more than 320 refereed journal papers and more than 230 conference papers to his name. Not only is his research group prolific, but his work is also consistently high in quality—evidenced by 14 best paper or best poster awards and 24 patents and patent applications.

Bjorn Borgen Professor Christian Franck was named a fellow of the Society for Experimental Mechanics as well as of the American Society of Mechanical Engineers. He specializes in cellular biomechanics and new experimental mechanics, including unique 3D microscopy techniques. Franck is director of the multi-institutional PANTHER program, supported by the U.S. Office of Naval Research, which is a global leader in developing better technologies for detecting and preventing concussions and other traumatic brain injuries.

Darryl Thelen, Bernard A. and Frances M. Weideman Professor and John Bollinger Chair of Mechanical Engineering, has received the Borelli Award, the most prestigious honor given by the American Society of Biomechanics. The award recognizes outstanding career accomplishment and is awarded annually to an investigator in biomechanics. Thelen's work focuses on understanding the biomechanics and neuromuscular coordination of human movement, with the goal of informing and improving clinical practices in orthopedics, rehabilitation and sports medicine.

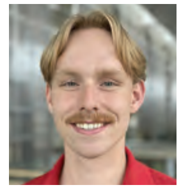
Peter Adamczyk, Mead Witter Associate Professor, received the Founders' Award from the American Society of Biomechanics, recognizing his scientific accomplishment in biomechanics and excellence in mentoring. His research aims to enhance physical and functional recovery from impairments affecting walking, running and standing.

Student news

The Wisconsin Autonomous team won second place overall in the fourth year of the SAE Autodrive Challenge II in summer 2025. Competing against top engineering schools from across North America (seven universities from the United States and two from Canada), the team showcased cutting-edge research, advanced software integration and the spirit of Badger engineering excellence. In the multi-year competition, hosted by SAE International and GM, select schools work to transform a Chevrolet Bolt into an autonomous vehicle. Each year the goals get progressively harder as teams construct and consider the variety of elements it takes to build a self-driving car.

The UW-Madison SAE Aero team competed in the SAE Aero Design Regular Class competition held in Van Nuys, California, in May 2025, where the team earned 22nd place in its first year competing. The three-day competition challenges teams to design an aircraft that can carry the highest payload possible while maximizing wingspan (within a 15-foot wingspan and 55-pound weight limit). "The biggest win for us was proving we could start from nothing, build a working aircraft, and make it to the competition in our very first year," says Aiden Brion, UW SAE Aero team president.

Ali Nabaa, a PhD student in the lab of Kuo K. & Cindy F. Wang Associate Professor Lianyi Chen, won the Outstanding Poster Award from the Metal Powder Industries Federation at the PowderMet2025/AMPM2025 conference. Only one poster was selected for this award. Nabaa's poster, "Thermocapillary-force driven pore elimination in powders for additive manufacturing," describes technology that has been patented by the Wisconsin Alumni Research Foundation.



The Astronaut Scholarship Foundation named Nicholas Rienstra, a senior in the engineering mechanics (+aerospace option) bachelor's program, a 2025 Astronaut Scholar. This honor is awarded to exemplary juniors and seniors pursuing degrees in the STEM field. Scholars not only receive up to $15,000 in financial support, but also gain access to a professional network of astronauts, alumni and industry leaders who are willing to mentor and offer advice to students. The scholars also participate in a variety of professional development opportunities, including leadership training, coaching, building business skills, and presenting cutting-edge research.

The Wisconsin Baja Racing team placed 7th overall, out of 107 teams, in the Baja SAE Competition in Mechanicsville, Maryland, in June 2025. Team president Cale Kubisiak says the team set a goal to improve in the maneuverability category by being able to disconnect the belt drive to the front wheels. Not only did the team achieve this goal, but it placed 16th in the maneuverability category, up from its 27th placement one year ago.

The UW Human Powered Vehicle team won first place overall in the ASME Human Powered Vehicle Challenge in North Carolina in April 2025. The UW-Madison eHPVC club team ended up on the podium for all three challenge events (first in endurance racing, second in drag racing, and third in the design challenge), culminating in first place overall among the eight schools participating. The team also won the Best Innovation Award for its tilting mechanism redesign of the vehicle for the second time.

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Mechanistic understanding could enable better fast-charging batteries

Fast-charging lithium-ion batteries are ubiquitous, powering everything from cellphones and laptops to electric vehicles. They're also notorious for overheating or catching fire.

Now, with a groundbreaking computational model, Alfred Fritz Assistant Professor Weiyu Li has gained new understanding of a phenomenon that causes lithium-ion batteries to fail.

Developed by Li, the model explains lithium plating, in which fast charging triggers metallic lithium to build up on the surface of a battery's anode, causing the battery to degrade faster or catch fire.

This knowledge could lead to fast-charging lithium-ion batteries that are safer and longer-lasting.

The mechanisms that trigger lithium plating, until now, have not been well understood. With her model, Li studied lithium plating on a graphite anode in a lithium-ion battery. The model revealed how the complex interplay between ion transport and electrochemical reactions drives lithium plating.

"Using this model, I was able to establish relationships between key factors, such as operating conditions and material properties, and the onset of lithium plating," Li says. "From these results, I created a diagram that provides physics-based guidance on strategies to mitigate plating. The diagram makes these findings very accessible, and researchers can harness the results without needing to perform any additional simulations."

Researchers can use Li's results to design not only the best battery materials—but importantly, charging protocols that extend battery life.

"This physics-based guidance is valuable because it enables us to determine the optimal way to adjust the current densities during charging, based on the state of charge and the material properties, to avoid lithium plating," Li says.

Previous research on lithium plating has mainly focused on extreme cases. Notably, Li's model provides a way to investigate the onset of lithium plating over a much broader range of conditions, enabling a more comprehensive picture of the phenomenon.