College of Engineering
UNIVERSITY OF WISCONSIN–MADISON

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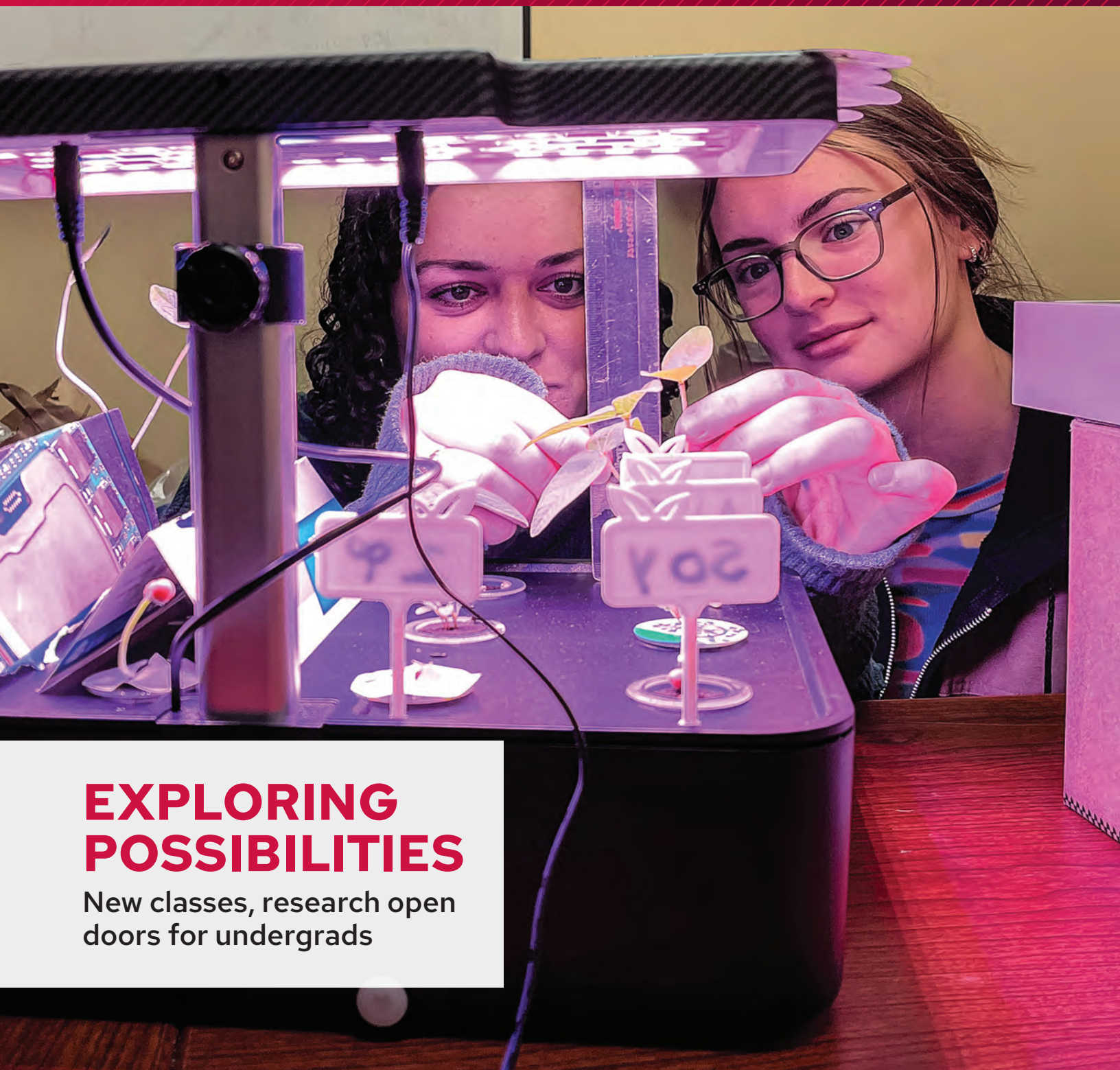
INDUSTRIAL AND SYSTEMS ENGINEERING



EXPLORING POSSIBILITIES

New classes, research open doors for undergrads

Greetings from Madison!

Spring is here, and with it comes a busy and fulfilling time of year on campus. As we prepare to recognize the next class of graduates, we also take a moment to look back on all we've accomplished as a department in the last several months.

One of our department goals is to introduce students to the host of opportunities that a degree in industrial engineering makes possible. In our undergraduate program, students develop the skills and tools needed to transform data into decisions. Their coursework prepares them to improve processes and systems in the world of healthcare, finance, business, manufacturing, or wherever their interests may lie. To share this message with our college's newest undergraduates, we recently hosted our first "ISyE Discovery Day." Alumni, faculty, seniors and graduate students were on hand to share their stories with first- and second-year engineering students interested in learning more.

For those students already enrolled in our degree programs, we continue to expand and adapt our program offerings in response to a changing world. Assistant Professor Hantang Qin introduced a new course last fall, *Biomedical Design and Manufacturing*, which gave students hands-on experience with technologies used in advanced manufacturing—in this case, for an application that could potentially grow plants in outer space. As a department, we've also introduced an honors in research option for undergraduates, an initiative driven in large part by the number of inquiries from students regarding research and graduate school.

In addition to the exciting developments in our undergraduate program, we continue to pursue research that is innovative, impactful and timely, such as the safe implementation of automation and artificial intelligence and solutions to recent supply chain and transportation challenges. Our faculty and graduate students frequently take advantage of the collaborative opportunities available on campus, partnering with other schools, departments and research centers to maximize our impact. Our diverse portfolio of research is one of the key contributors to our department's continued world-class reputation as a leader in higher education.

Looking ahead, we plan to see continued growth in our department, both in terms of student enrollment and research activity, and we are ready for the challenge. We're expanding our scholarship and support programs for students and working hard to recruit additional faculty. I hope to introduce them soon.

I hope you enjoy the stories and department updates contained in the following pages. We are always happy to hear from alumni and friends, and encourage you to reach out to us with questions about our efforts or with updates about your own activities. As always, thank you for your interest in, and support of, our department.

On, Wisconsin!

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Undergraduate Q&A: **Ava Schmidt**

Ava Schmidt is a Milwaukee native who's thrilled to have discovered the field of industrial engineering. The senior shares insights about her engineering education.

What drew you to industrial engineering?
Going into my first year at UW-Madison, I knew nothing about industrial engineering. I started off studying mechanical engineering, but quickly found myself interested in the consideration of people when designing and improving systems. I enjoyed solving problems that forced me to think about many factors. When I learned about industrial engineering from a classmate, I quickly made the switch!

What have been the highlights of your education?
I am so grateful for the staff and student body that make up the ISyE department. Professors and teaching assistants have always been excited to answer questions, tell stories, and offer insight on anything IE-related. It is clear to me that industrial engineering draws a particular kind of person, someone who is curious, insightful, and fundamentally driven by helping and interacting with others.

What's been your favorite course?
I really enjoyed taking ISyE 323, *Operations Research-Deterministic Modeling.* While I found the course to be challenging, I was really interested in the problems I was asked to solve. Before taking this course, I had no experience with optimization. I learned that it's pretty awesome (not to mention useful) to be able to provide the most optimal solution for almost any mathematical scenario you can think of, from bus stop locations to staffing in a restaurant.

What is something most people don't realize about industrial engineering?
I am a firm believer that the opportunities in this discipline are endless, and because of that, it can be hard to explain to others what we do. How do you explain a field of study that produces bankers, government workers, CEOs, designers, data scientists, healthcare professionals, manufacturers and everything in between?

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From left to right, students Greyson Wainwright, Josie Beres and Rayne Wolf work on a desktop hydroponics system, one of several hands-on group projects in *Biomedical Design and Manufacturing.*

New course puts design, manufacturing into students' hands

Rayne Wolf, Josie Beres and Greyson Wainwright huddle around a desktop hydroponic system, inspecting the growth of alfalfa, mung beans and soybeans.

Later in the fall 2022 semester, some of their classmates will design and 3D print a component of an automated system for potentially growing plants in space.

If that doesn't sound like your typical assignment for an industrial engineering course … well, that's because *this isn't* your typical industrial engineering course, as the name, *Biomedical Design and Manufacturing,* makes clear. While the plant-growing project veers into the biological sciences (another team project has students 3D printing models of human bones), the idea is to give students hands-on experience with technologies used in advanced manufacturing, along with tangible design challenges to solve.

At a more fundamental level, Assistant Professor Hantang Qin also hopes to inspire students to cultivate an inventive mind, along with other broadly applicable skills like teamwork and leadership.

"When we talk about design, innovation is important. You don't follow standard rules. We teach a few guidelines. You have to be creative," says Qin, who brought the course to UW-Madison after teaching it for several years as a faculty member at Iowa State University.

In the course, undergraduate and graduate students learn manufacturing and design fundamentals, predominantly in the context of biomedical applications. They get a crash course in anatomy and biomaterials, review existing research studies and consider ethical questions that arise in the biomedical field. And throughout the semester, they get plenty of practice in 3D modeling and design software they may use in their future careers. Qin hopes to draw students from a range of engineering disciplines beyond industrial, particularly biomedical and mechanical, as well as from the health sciences.

As part of their coursework, students can earn official certificates in SOLIDWORKS, a widely used software for computer-aided design and additive manufacturing. The cost of the certification exam, which served as one of the course's midterms, is also covered as part of the class.

"It's an awesome thing to put on your resume, because a lot of people say they have SOLIDWORKS experience, but to actually have that stamp of approval from the company itself saying you're certified in modeling with their software says a lot," says Wolf, a first-year master's student from Potosi, Wisconsin. She's hoping to eventually work on the data science or technology side of the manufacturing industry. "It will be especially useful in future positions."

Wainwright, a junior from Lynnfield, Massachusetts, signed up for the course in hopes of broadening his perspective. In that regard, the course has delivered, even exposing students to Qin's research on optimizing 3D printing for in-space manufacturing.

"We've done a whole slew of things," says Wainwright, who's planning to pursue a career in healthcare engineering. "We've learned a lot about mechanical design, we've learned a lot about manufacturing and 3D printing. It's a lot that I hadn't realized could be necessarily under industrial engineering."

The students spent one class session visiting the Waisman Center, touring labs to get ideas about applications of industrial engineering tools to neurodegenerative disease diagnosis and treatment. Qin is a proponent of connecting students to real-world use cases, both in academic research and industry settings.

In the future, Qin has designs on developing similar hands-on courses in robotics and automation. He plans to dust off a previously dormant teaching lab on the second floor of the Mechanical Engineering Building that's stocked with machining, production and quality monitoring equipment.

"This is just the start," he says.

Mintz creating framework for safe, ethical AI

Artificial intelligence is spreading across industries, handling tasks like credit card and insurance approvals, assisting with medical diagnoses, driving autonomous vehicles, and even writing stories. Before long, AI could make scheduling and pay decisions in a workplace and quickly spit out personalized treatment plans for patients.

However, AI carries serious risks along with its tantalizing potential to unlock new levels of efficiency and precision. Algorithms can perpetuate existing biases, inequalities and falsehoods. Errors in autonomous vehicles can have deadly consequences. And applications like facial recognition software could easily infringe upon privacy.

Navigating those safety and ethical concerns requires intentional consideration during the development process, which is where Assistant Professor Yonatan Mintz hopes to influence the field.

"I'm an engineer, I'm a technologist, I'm a techno optimist at heart," says Mintz, whose research includes safety, fairness and transparency in AI. "I want this stuff to work."

For AI to succeed in achieving widescale societal acceptance, though, companies, organizations, academics and even governments will need to develop policies and mechanisms to prioritize safety and ethical use and allow for public feedback.

Historically, Mintz notes, companies have largely self-regulated, relying on internally created ethics boards to conduct reviews—though the European Union is working on its proposed AI Act and a number of U.S. states and cities have in recent years introduced or passed bills toward varying levels of oversight. Still, in an MIT Sloan Management Review and Boston Consulting Group study published in September 2022, just 52% of the more than 1,000 managers surveyed reported their organizations had "responsible AI" programs in place (and 79% of those programs were limited in scale or scope).

"It's good to regulate yourself, but if you're the only one answering to yourself, it's like letting the mice regulate the cheese storage," says Mintz, who in November 2021 coauthored a paper in the journal *Artificial Intelligence* laying out a framework for working through "hard choices" in AI development.

He says documenting the rationale behind those choices—often made between comparable competing options—and creating ways to respond to future feedback from the humans interacting with AI systems are two keys.

To facilitate progress on the latter front, it's important to understand the differences in the ways humans think about and solve problems compared to AI algorithms. In that vein, Mintz has joined a research project exploring those differences and the gaps they create using a unique game environment that challenges players—human or AI—to clear a grid of pieces while learning the game's hidden rules at the same time.

"So you could actually get close to apples-to-apples comparisons on performances between algorithms and humans on basically the same task," he says.

Assistant Professor Yonatan Mintz, left, and PhD student Eric Pulick are exploring ways to compare how humans and AI algorithms solve problems through a computer-based game called "The Game of Hidden Rules."

In the interdisciplinary project, sparked by colleagues Vicki Bier and Paul Kantor, Mintz and PhD student Eric Pulick are working on ways to compare human and AI players. How can humans and machines best communicate and collaborate on problems? It's fundamental research that could inform efforts to make AI technology more receptive to stakeholder feedback.

Through his work in the lab and the classroom, Mintz hopes to nudge the direction of future AI development toward more fully integrating considerations of safety, transparency and ethics.

"We're a leader in analytics and data science here at UW-Madison," he says. "The students who are in our classes today are going to end up in regulatory positions in government, as tech leads in Silicon Valley, and as professors developing future technology. These are the people that I want to get on board."

Assistant Professor Justin Boutilier and undergraduate student Katherine Breen are working with Kenya-based Keheala to assist tuberculosis patients.

New program helps undergrads explore research

Over the course of three years spent working on the same research project, undergraduate Katherine Breen made a fundamental self-discovery that went beyond any data she'll publish.

"I decided I really liked the research process," she says.

Since her sophomore year, Breen has worked on a project in the lab of Assistant Professor Justin Boutilier studying tuberculosis recurrence in Kenya. The research is part of a collaboration with Keheala, a mobile platform that helps patients manage their conditions by delivering reminders to take medications and providing other support.

With mentorship from Boutilier, she's been able to stretch her independence as a researcher, reviewing existing literature, using machine learning and other computer science techniques to format often-messy data, analyzing recurrence rates, and turning it all into a coherent written thesis.

It's an experience that's inspired her to pursue a PhD at the intersection of computer science and healthcare. And it's an experience the department hopes to replicate for other undergraduates who are serious about exploring pathways in research.

ISyE is launching a new honors in research option for undergraduates to formalize that experience, give students a tangible credential for their extra efforts, and teach them about the research process and graduate school opportunities.

"The creation of this was really driven by students, honestly—not anything that they necessarily knew that they were asking for, but we've had so many students who want to get involved in research as undergrads," says Amanda Smith, an assistant teaching professor and the department's associate chair for undergraduate affairs.

Participating students will take two courses covering the fundamentals of research—like conducting literature surveys, writing proposals and presenting research in different formats—and preparing for graduate programs. The department will pair students with relevant faculty mentors, in whose labs they'll conduct research leading to a senior thesis and poster presentation during an annual research showcase event.

That structure was partly inspired by the Department of Engineering Physics, which offers a thesis experience as part of one of its undergraduate majors. In fact, despite working in an ISyE faculty member's lab, Breen is actually an engineering physics major with a focus on scientific computing, in large part because she specifically wanted the challenge of completing a thesis project. When she was combing through research options, she came across Boutilier's lab, which applies optimization and machine learning techniques to improve healthcare access and delivery.

"I would never have learned about this whole area that I'm now very interested in and want to have a career in," says Breen, who's also a member of the UW rowing team. "It's also set me up very well for graduate school, because I know about the research process. I've done a whole project, so when I'm writing applications, I can talk about all the stuff I've done."

Smith sees the new program as a way to both expose students to current trends in the field and add enthusiastic young researchers to faculty labs.

"It is a really great way for students to see what is actually being done in modern industrial engineering," she says. "It's helpful for the people who are running the project because it reduces their workload, and it's helpful for the students to see what's really going on and how challenging it is to solve real, open questions and not textbook problems that have nice clean answers."

PhD student brings statistical skills to helmet liner research

Abhijeet Bhardwaj is drawn to interesting problems where he can apply his statistical skills to unearth solutions.

So when a friend and fellow engineering PhD student told Bhardwaj about a project devising an improved foam material for helmets, his interest was piqued.

Bhardwaj wound up conducting statistical analyses to support experimental work by researchers in the lab of Ramathasan Thevamaran, an assistant professor of engineering physics. The group published a paper in the journal *Extreme Mechanics Letters* detailing a lightweight, ultra-shock-absorbing material that could vastly improve helmets designed to protect people from strong blows.

"I have always felt that the underlying mathematics and statistics remains constant," says Bhardwaj. "If you have a knowledge of that, you can go help people with their problems, be it from any domain."

Bhardwaj, a member of E-Business Chair Professor Raj Veeramani's research lab, was taking his final course toward a master's degree in statistics (a common path in Veeramani's group), which entailed a required collaborative project with other UW-Madison researchers.

Abhishek Gupta, a PhD student in Thevamaran's lab and friend of Bhardwaj's, had previously told him about their group's challenge of trying to optimize design parameters for their carbon nanotube foam. After contacting Thevamaran and taking a month or so to review previous publications and familiarize himself with the context of the project, Bhardwaj began analyzing the group's experimental data.

Abhijeet Bhardwaj

His work provided a statistical backing for the researchers' testing of design parameters—thickness, inner diameter and gap between nanotubes—to achieve the best energy absorption.

The new material exhibits 18 times higher specific energy absorption than the foam currently used in U.S. military combat helmet liners, as well as having much greater strength and stiffness, which could allow it to provide improved impact protection.

Physical forces from an impact can inflict trauma in the brain, causing a concussion. But helmet materials that are better at absorbing and dissipating this kinetic energy before it reaches the brain could help mitigate, or even prevent, concussions and other traumatic brain injuries.

The researchers' industry partner, helmet manufacturer Team Wendy, is experimenting with the new material in a helmet liner prototype to investigate its performance in real-world scenarios. The researchers are also patenting their innovation through the Wisconsin Alumni Research Foundation.

In his PhD research, Bhardwaj is extracting useful textual data from manufacturing machine failure logs to derive prognostic analyses and guide maintenance decisions. It's a drastically different application from the helmet liner research, which showcases the adaptability of industrial engineering methods across sectors.

"Industrial engineers face many problems, and industrial engineering is not specific to one kind of industry, not necessarily just manufacturing," says Bhardwaj, who plans to pursue a research-oriented career after completing his PhD in May 2023. "It could be any industry with multiple problems."

Faculty News

Professor Laura Albert, the David. H. Gustafson Department Chair, served as the keynote speaker at the College Research Symposium on Homeland Security, hosted by Kennesaw State University.

Justin Boutilier, the Charles Ringrose Assistant Professor, was a finalist for the Pierskalla Award, presented by the Health Applications Society of the Institute for Operations Research and the Management Sciences (INFORMS), for the third straight year.

Assistant Professor Tony McDonald is part of a research project looking at remote-controlled trucks as an option to alleviate pressure on our nation's trucking industry. The three-year, $1.7 million project, funded by the National Science Foundation (NSF), involves a cross-disciplinary team of researchers from across the college.

Robert Radwin, the Duane H. and Dorothy M. Bluemke Professor, is part of a collaborative ergonomics project funded by the National Institute for Occupational Safety and Health. He will work to create a computer vision risk model for manual lifting and incorporate it into a prototype instrument.

Assistant Professor Xin Wang received the Best Publication Award in Energy from INFORMS for his collaborative work on the paper "Charging an electric vehicle sharing fleet." The paper was published in the journal *Manufacturing & Service Operations Management.*

The Society of Risk Analysis honored Professor Emeritus Vicki Bier with its 2022 Distinguished Educator Award.

Student News

PhD student Katherine Adams earned the Bonder Scholarship for Applied Operations Research in Health Services at the 2022 INFORMS annual meeting. This award, considered one of the most prestigious for graduate students applying operations research and management to questions in healthcare, supports the development of promising researchers.

PhD student Rebecca Alcock was named among the "2022 Rising Tech Leaders to Watch" by *Milwaukee Business Journal.*

PhD student Hanna Barton received a student member with honors award from the Human Factors and Ergonomics Society.

PhD student Weijun Shen was chosen as a future faculty fellow by the Institute for Industrial and Systems Engineers. The program is designed to prepare PhD students for future positions in academia.

Our student chapter of INFORMS was recognized at the cum laude level for the third year in a row, while our HFES group earned another Outstanding Student Chapter Gold Award.

CHESS partners in new opioid research outreach effort

Across the country, countless experts across government, academia and the private sector are aggressively seeking solutions to the nation's opioid crisis. All of that research makes the biggest impact when it actually reaches people affected by or dealing with opioid dependence.

That's the goal for the HEAL Research Dissemination and Engagement Center, a new multi-institutional effort funded with a $21 million grant from the National Institutes of Health HEAL (Helping to End Addiction Long-term) Initiative. The Center for Health Enhancement Systems Studies (CHESS), based in ISyE, is a partner in the center, which aims to deliver lay-friendly, culturally appropriate information about the latest scientific findings to communities most affected by the pain, opioid and overdose crises.

CHESS, founded by Professor Emeritus Dave Gustafson, is internationally known for applied research in addiction, recovery, disease and aging.

Created in 2018, NIH HEAL seeks to accelerate scientific solutions to stem the national opioid public health crisis. It's focused on improving prevention and treatment strategies for opioid misuse and addiction and enhancing pain management.

A key component of the new research and dissemination center is to build bridges between HEAL researchers and community partners and share research findings with communities impacted by the opioid epidemic—including clinicians and community care providers; advocacy groups with interest in pain, addiction and areas such as mental and behavioral health; and service organizations or community-based organizations in HEAL's scientific focus areas. A focus on health equity will underpin the center's work at every level.

Todd Molfenter, a co-director of CHESS, is a center co-investigator and will support its community and stakeholder engagement efforts.

"We are excited to support the Research Dissemination and Engagement Center with the culturally informed technical assistance tools that we have developed through related research projects," he says.

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Helping students discover ISyE

The career possibilities with a degree in industrial engineering are endless. We want to make sure students understand that—which is why we hosted our inaugural "ISyE Discovery Day" on campus in January 2023.

Alumni, faculty, staff, graduate students and undergraduates spent the afternoon chatting with students about the opportunities available in the field. Industrial engineering graduates pursue careers in business, manufacturing, research, healthcare systems, government, finance, and much, much more.