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IOWA STATE UNIVERSITY
Department of Mechanical Engineering

Letter From the Chair

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On the cover

A student examines a 3D-printed sensor inside the lab of Carmen Gomes, associate professor of mechanical engineering. The research in Dr. Gomes's lab focuses on both fundamental and more immediately applied research in functional delivery systems and biosensors in the areas of food safety, shelf-life extension of food products and nutrient bioavailability. The overall research emphasis is to design novel nanoscale materials using biopolymers for biotechnology and food applications.

Front cover photo by Dan McClanahan

Back cover photo by Nick Fetty

Dear alumni and friends,

It was a little over a year ago when COVID-19 first entered our lexicon and became something that would impact nearly every aspect of our everyday lives. I'm encouraged that after a challenging year we appear to be rounding the corner on this horrible pandemic, and I couldn't be prouder of the way that students, faculty and staff have conducted themselves during these challenging times. As a department, we have established COVID-19 Heroes Awards as a way of recognizing those who have gone above and beyond in their service to our department during the era of COVID-19. A full list of award recipients is included in the following pages.

In this magazine you will also read about:

- Vignesh Suresh, an ME graduate student who served as student marshal for the Graduate College during commencement, as well as David Reynolds, an undergraduate in ME who was the department's Outstanding Senior for Spring 2021;
- Researchers at Iowa State University have teamed up with Vermeer Corporation to study and improve machine wear and tear;
- Olivia Tyrrell, an undergraduate ME student, attributes her undergrad research experience as paving her way for the internship she currently has with NASA;
- Robert Brown, a distinguished professor of ME, is busy concocting beer in his at-home brew lab when he's not busy conducting research for the Bioeconomy Institute;
- Margaret Harding, a graduate of the nuclear engineering department, discusses the importance of effective communication skills for engineers;
- Michael Olsen, a professor of ME, is applying his ME knowledge to the field of pharmaceuticals for a project he has with Pfizer;
- The ME department is overseeing a new undergraduate minor program known as Cyber-Physical Systems, which organizers hope will prepare students for careers in "the fourth industrial revolution;"
- ME alum John Lawson climbed the career ladder with John Deere during his four-decade career with the company. Now in retirement he and his wife are doing all they can to give back to the university they hold near and dear to their hearts.

We hope that for our next magazine, COVID-19 will be less of a theme. We hope that our students might return to in-person classrooms as well as study abroad, internships/co-ops, student club competition, and other opportunities that allow them to leave campus. However, we're fully aware that our new sense of normalcy might differ from what we were once used to.

Our alumni are vital to the growth and success of mechanical engineering and industry in the U.S. and abroad. I enjoy hearing about your accomplishments and encourage you to reach out and share your story. I can be contacted at mealumni@iastate.edu.

Regards,

Caroline Hayes
Mechanical Engineering Department Chair
Lynn Gleason Professor of Interdisciplinary Engineering

Department Honors

Students

Saurabh Aykar *Graduate Student*
First Place People's Choice at the Research Days 2021 iPoster competition hosted by ISU's Office of the Vice President for Research

Jessica Brown *Graduate Student*
Named "Best Commercialization Potential" at the Research Days 2021 iPoster competition hosted by ISU's Office of the Vice President for Research

Emily Johnson *Graduate Student*
FRC Best Presentation Award at WCCM-ECCOMAS2020

Charlie Kolar *Undergraduate Student*
Wallace E. Barron All-University Senior Award

Justin Lajoie *Graduate Student*
Received a SMART Fellowship from the U.S. Department of Defense for research on development of propellants for enhanced microwave interaction and control

David Reynolds *Undergraduate Student*
Named Outstanding Senior from ME for Spring 2021 by ISU College of Engineering

Hamidreza Zobeiri *Graduate Student*
Named Brown Graduate Fellow by the ISU Office of the Senior Vice President and Provost for 2021-22

Taylor Brown, Adam Burke, Justin Christoffersen, Josh Curtis, Matt Dodge, Cole Jacobson, Sari Lewinsky, Erik Rees, Sam Stark and **AJ Young**
Undergraduate Students
Received ME 324L Undergraduate Teaching Assistant CYtation Awards

Blaise Brown, Steven Biegler, Ronald Harms, Boyoung Jin and **Nicholaus Steffensmeier**
Former Undergraduate Students
Received Patent US10981773 in collaboration with Artistic Manufacturing Corporation (based in Altoona, Iowa)

Makrand Khanwale, Humair Nadeem, and **Yi Zheng**
Graduate Students
Received Research Excellence Awards, from the ISU Graduate College for Spring 2021

Soheila Shabanaverki and **Harish Radhakrishnan**
Graduate Students
Received Teaching Excellence Awards, from the ISU Graduate College for Spring 2021

Abigail Arens *Undergraduate Student*
Nick Hunter, Joel Lynch, Roy Pillers and **Hamidreza Zobeiri**
Graduate Students
Received ME COVID-19 Heroes Awards

Faculty and Staff

James Dautremont *Electronics Technician*
Iowa State University 35-year Service Award

Mathew Hagge *Associate Teaching Professor*
#CyThx 2020 Honoree from Center for Excellence in Learning and Teaching

Nicole Hashemi *Associate Professor*
Named Fellow of the American Society of Mechanical Engineers (ASME)

Alyssa Mittleider *Academic Advisor*
#CyThx 2020 Honoree from Center for Excellence in Learning and Teaching; ISU Award for Academic Advising Impact from Office of the Senior Vice President and Provost

Cary Pint *Charles Schafer (Battelle) Chair in Engineering*
#CyThx 2020 Honoree from Center for Excellence in Learning and Teaching

Paul Schafbuch *Professor of Practice*
Mechanical Engineering Professor of the Year, Awarded by Pi Tau Sigma

Jim Shelledy *Teaching Laboratory Coordinator*
#CyThx 2020 Honoree from Center for Excellence in Learning and Teaching

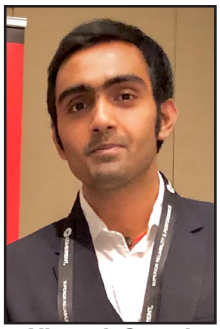
Eliot Winer *Professor*
#CyThx 2020 Honoree from Center for Excellence in Learning and Teaching

Jim Dautremont *Electronics Technician*
Josh Delarm *Teaching Labaratory Specialist*
Nick Fetty *Communications Specialist*
Mindy Heggen *Academic Advisor*
John Howell *Teaching Labaratory Specialist*
Nate Jensen *Systems Analyst*
Katie Lott *Administrative Specialist*
Wyman Martinek *Teaching Labaratory Specialist*
Sandy Sayer *Program Coordinator*
Cris Schwartz *Associate Professor*
Taylor Schweizer *Teaching Labaratory Specialist*
Craig Severson *Teaching Labaratory Specialist*
Jim Shelledy *Teaching Labaratory Specialist*

Received ME COVID-19 Heroes Awards

ME's Suresh to serve as Graduate College student marshal for Spring 2021

Vignesh Suresh has racked up a handful of awards and honors during his time at Iowa State, and he nabbed one more just in time for graduation.



Vignesh Suresh

Suresh, a Ph.D. candidate in mechanical engineering (ME) and human-computer interaction, was named a student marshal for the Spring 2021 Ph.D. commencement ceremony. He will be among the first from the department to receive this honor when he walks across the stage on May 7.

"I didn't even know that I had been nominated so when I found out I would receive this honor, I was like 'wow,'" said Suresh. "This was really a surprise to me, and I feel like it's a great honor to be named the student marshal by the Graduate College."

Being named student marshal is just the latest honor Suresh has received during his four years at Iowa State University. He has also received the College of Engineering Research Excellence award, the Graduate and Professional Student Senate Research Excellence award and the William and Virginia Binger Research award, as well as the Best student paper award at SPIE Photonics West Conference 2019 and a SPIE Defense + Commercial Sensing student travel grant.

Suresh is from the Tamil Nadu state in South India. He attended the PSG College of Technology in his home state and completed his B.S. in ME in 2015. After graduation he worked for two years in the research and development department of TVS Motors, an automotive manufacturer in India.

He decided he would need to pursue an advanced degree to achieve his professional goals, so he began looking at graduate ME programs in the United States. He said it was the research opportunities available within the ME department that led him to choose Iowa State University for pursuing his Ph.D.

When Suresh arrived in Ames on August 11, 2017, it was his first time in the United States. The friendliness of the people was one of the first things he observed when adapting to his new life in a foreign land.

"One of my neighbors in the apartment cooked food for me and my roommates that first night," said Suresh. "The bond between me and Ames started off on a positive note because of that. I found the people here to be so welcoming."

He also found the climate on campus to be very welcoming. He quickly found a research niche for himself under the guidance of **Beiwen Li**, assistant professor of ME. Suresh's research focuses on novel 3D optical solutions, developing new calibration methods and developing algorithms for 3D imaging. He often applies material from courses such as ME 556: Machine Vision, ME 592: Data Analytics and Machine Learning for Cyber-Physical Systems Applications and ABE 690: Visual Sensing and Sensemaking to his research.

He said that his graduate committee – which consists of **Sarah Bentil**, **Abhijit Chandra**, **Beiwen Li**, **Jim Oliver** and **Eliot Winer** – has also contributed to his professional development.

"Their feedback has been very constructive which has helped me to develop into a better researcher," Suresh said.

Suresh is involved with various other campus activities when he's not busy in the classroom or lab. He relieves stress by playing badminton and exercising regularly at the campus recreation facilities, even during this era of COVID-19.

"I really appreciate the effort from the people working in rec services," said Suresh. "They clean the equipment all the time and are really doing a great job. Just having these facilities open again, albeit with some modifications for safety, it gives life a sense of normalcy again."

He also enjoys watching cricket, which is often regarded as the most popular sport in his home country. He even has a subscription to a streaming service which allows him to watch matches for the Indian national team as well as Chennai Super Kings in the Indian Premier League.

Suresh also embraces his Indian roots through the Mana Telugu Association, a student organization he established with some friends last year. The club aims to introduce Telugu culture, which dates back to the 6th century, to anyone in the Iowa State University community who is interested. Suresh, who currently serves as the club's president, said that organizing the Sankranti event has been one of his fondest memories from his time at Iowa State.

"It was a lot of work but when we saw the final event actually happening with more than 80 people there it was really a great feeling," he said, adding that publishing his first paper and winning his first award are also among his fondest memories from his time in Ames.

After graduation, Suresh would like to work in industry where he can continue conducting research and publishing papers. Specifically, he's interested in doing research in the field of computer vision. While he has enjoyed his time in the Midwest, he admits the winters have been harsh, particularly for someone acclimated to the climate of South India, so he's hoping he might end up on the American west coast for the next chapter of his life. However, he said he will never forget about that first home cooked meal he had in Ames, or any of the other memories he's developed during his time here.

"People might think it's a myth, but I've seen the whole 'Iowa nice' thing firsthand and I can say the people of this state are great," he said.

David Reynolds

Outstanding senior in mechanical engineering

Major: Mechanical engineering

Hometown: Grand Island, Nebraska

Clubs and Activities: Undergraduate research with Espin Laboratory with Raquel Espin-Palazon, assistant professor of genetics, development, and cell biology; University First-Year Honors Program Research Advisor; Grand Island Public Schools (COVID-19 Sack Meals); PrISUm Solar Car; International Student Council; SolidWorks Help Session Leader; Freshman Honors Program Leader; IMPACT; Freshman Leaders in Engineering

Awards and honors: National Collegiate Honors Council Portz Scholar Finalist, Stanford University ADVANCE Undergraduate Institute Scholar, Barry Goldwater Scholarship Campus Nominee, Cargill Global Scholars Program Cohort 7 Alternative/Semifinalist, Fulbright UK Summer Institute Semifinalist, Stewart Research Award, University Honors Program Grant, First-Year Honors Mentor Program Grant, The Boeing Company Fund Scholarship, Iowa State University Engineering Study Abroad Scholarship, Henry M. Black Scholarship, Iowa State Competitive Excellence Scholarship

Research honors: Published first author and co-author in the Royal Society of Chemistry Interface Focus, Royal Society of Chemistry of Advances, and Blood. Invited researcher for the Harvard University for National Collegiate Research Conference, Microfluidics for Hematology at University of Chicago, National Conference for Undergraduates Researchers, and University of Pennsylvania CEMB Research Symposium.

Who was your most influential mentor while at Iowa State?

Between all of my mentors, I would probably choose Laura Good, the former nationally competitive awards coordinator.

What would you consider your greatest accomplishments at ISU?

Publishing my first paper in the Royal Society of Chemistry Interface focus, as this a pivotal moment in my research career.

What's your favorite memory of your time at Iowa State?

Studying abroad in Sydney, Australia, at the University of New South Wales. One of the best experiences I have had yet in my life.

What's your favorite place on campus?

The labs on the second floor of Hoover Hall. I spent lots of time (pre-COVID) doing homework and meeting students in these rooms/labs.

What's your advice for first-year students just starting at Iowa State engineering students?

Be open-minded to meeting new people and taking risks throughout your undergraduate career.

What do you like to do in your free time?

I love to travel, attend concerts and festivals, bicycle, cook, read, and hang out with friends.

What's one lesson you're taking away from this challenging pandemic year?

Family is everything. Without family, times like these are much harder to endure.

What are your plans for after graduation?

I plan to attend a Ph.D. program in bioengineering, biomedical engineering or medical engineering. I have interviewed with MIT & Harvard University, Caltech, UPenn, and a few other programs

Contributed by Sierra Hoeger/Engineering College Relations

Iowa State University, Vermeer Corporation team up to study machine wear and tear

Issues caused by wear and tear on rotating machinery could be easier to detect and predict because of a research partnership between Iowa State University and Vermeer Corporation.

Chao Hu

Vermeer Corporation is the manufacturer of iconic yellow iron seen on industrial jobsites and farm fields worldwide. The team has manufacturing facilities and regional offices around the world but is headquartered in Pella, Iowa. Vermeer does important work in the agriculture, fluid management, landscape, pipeline, recycling, surface mining, technology solutions, tree care, utility installation, vacuum excavation and wood waste industries.

Chao Hu, assistant professor of mechanical engineering (ME), and his team of student researchers have been integral in this two-phase project which began in September of 2019. During the project's first phase, the Iowa State University researchers focused on developing a rotor balancing method, capable of detecting and correcting an unbalance of a rotor-bearing system. Unbalance occurs in these systems when the center of mass, or center of gravity, of a rotor deviates from its axis of rotation.

"Many of the machine faults and failures are caused directly or indirectly by excessive vibrations generated due to unbalances in rotor systems," said Hu. "Hence, it is of critical importance to monitor such vibrations and reduce them through timely, accurate, and cost-effective balancing when a machine operates in the field."

The researchers relied on mechanical engineering concepts and methods such as design of bearing and shaft components during this initial phase. Hu, who teaches these concepts and methods in ME 325: Mechanical Component Design, said this knowledge was helpful in understanding the operating principles and characteristics of the rotor-bearing system. The research team also applied concepts of machine health monitoring to the algorithm development for rotor balancing. This is the kind of content Hu covers in ME 591X: Probabilistic Engineering Analysis and Design, a course that he first developed and offered in Spring 2018.

Nazli Javadi Eshkalak, a second-year Ph.D. student in ME, and Hao Lu, a third-year Ph.D. student co-majoring in ME and electrical engineering, as well as a handful of undergraduate students contributed to this first phase. Eshkalak conducted a literature review to get better insight on shaft balance monitoring and the methods used to detect and correct shaft unbalance.

Nazil Javadi Eshkalak

"I tried to develop an algorithm which could detect whether or not the rotating shaft was unbalanced and consequently could specify the correction weights that were required to be placed on the rotor to minimize the initial vibrations of the rotor system," said Eshkalak, adding that the developed algorithm was verified by conducting experiments on a test stand at the Wind Energy Systems Laboratory on the Iowa State campus. The test stand had been designed and built by the Vermeer team.

During phase two the researchers will extend the findings from phase one to other types of machine faults, with the hope of developing an automated, field-deployable tool for onboard machine health monitoring.

"The basic idea of this tool is to process and analyze, in almost real-time, sensor data collected from operating machines to provide transparency to machine health and achieve near-zero breakdown performance," Hu said.

Eshkalak again contributed to phase two by reviewing applicable literature, this time with the help of first-year ME Ph.D. student Adam Thelen, who was an undergraduate ME student during the early research for this project.

"To detect failures before they occur, we need to understand some fundamental physical properties of the rotor as they relate to common failure modes," said Thelen. "Our goal is to combine knowledge of the physical properties of the rotor with real world data to aid in diagnosing faults."

Thelen, who has also been reviewing literature about rotor fault detection and diagnosis algorithms in preparation for creating a system, said material he learned in ME 370: Engineering Measurements and ME 573: Random Signal Analysis and Kalman Filtering has been directly applicable to this project. This project falls within the ME department's strategic research area of Computational Sciences.

Continued on page 7

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"The uniqueness of this type of project lies in the synergistic integration of data science and traditional ME that creates research and development opportunities to develop data-driven decision making technologies that help improve the competitiveness of the manufacturing industry," Hu said.

Adam Thelen

Carey Novak, project manager for Iowa State University's Center for Industrial Research and Service (CIRAS), is also involved in this project by serving as the liaison between industry partners and faculty and students from Iowa State's College of Engineering. One way CIRAS helps smooth the path for companies to grow is by matching them with the correct expertise for research at Iowa State. Novak has been working specifically with Hu in recent years on various company-sponsored projects.

"Dr. Hu's group is advancing the science of machine learning and are producing great journal and conference articles from their research, part of which is supported by NSF," said Novak. "But there are also potentially very significant commercialization opportunities in using machine learning for monitoring and predicting the health of industrial machines and equipment."

In addition to the support from the students and faculty involved, engineers from Vermeer have also contributed to the project. Steve Daining, a senior project engineer for Vermeer Corporation and a mechanical engineering graduate of Dordt College in Sioux Center, Iowa, overseas Vermeer's Power Systems and NVH team and leads the collaboration with ISU on this project.

"There is an expectation from our customers that data should equip them to operate more productively and maintain their machines more reliably. Our goal was to make a proof of concept that demonstrated that data could protect rotating working tools at the core of many Vermeer machines," said Daining, adding that early on, both ISU and Vermeer understood the common value in placing a high priority on development rather than focusing on research.

"The test stand allowed the ISU team to develop and test algorithms on a scaled system and allowed Vermeer to easily transfer that work into a full size prototype. The delivery of operational software was an important measure of success," Daining said.

Creating sustainable relationships with industry partners has been one of Hu's goals in his research lab.

"Such university-industry partnerships help university researchers identify industry-relevant research problems and greatly improve the direct transferability of university research," said Hu, "It has been quite rewarding for my students and myself to see our work transition to practical implementation and produce real-world impacts."

The next step will be for the ISU researchers to assist the Vermeer team in validating and implementing the machine health monitoring tool on some of the Vermeer machines.

The research team aims to have the projected wrapped up by August 2021.

"Vermeer is a smart company. It has developed a multifaceted relationship with the College of Engineering by supporting capstone projects, hiring interns, and sponsoring R and D projects in areas like machine learning and monitoring machine health. Smart companies know that working with Iowa State can be a great strategy for finding new talent and technology," said Novak.

***Chao Hu** oversees the **System Reliability and Safety Laboratory (SRSL)** at **Iowa State University.** SRSL focuses on using probabilistic and statistical methods to enhance the reliability, resiliency, and sustainability of complex engineered systems. The research group has graduated three PhD students and one MS student, and hosted one postdoc. It currently has one postdoc and eight PhD students (including two co-advised students). The research expertise of SRSL is in the areas of engineering design under uncertainty and post-design failure prognostics and has applications within lithium-ion batteries (energy storage), rotating machinery, and large-scale structural systems.*

For more info about the System Reliability and Safety Laboratory, visit:

me.iastate.edu/chaohu

Advancing rocket science with the U.S. Air Force Research Lab


Sarah Bentil

Sometimes people joke that "it's not rocket science" when referring to a non-technical matter. For one of mechanical engineering's junior faculty members, her summer research experience with the U.S. Air Force Research Lab was in fact rocket science.

Sarah Bentil, assistant professor of mechanical engineering (ME), spent 12 weeks during the 2020 summer participating in the U.S. Air Force Research Lab (AFRL) Summer Faculty Fellowship Program (SFFP). (**Meng Lu**, associate professor with appointments in ME and electrical and computer engineering at Iowa State University was also part of the 2020 SFFP cohort.) Due to the pandemic, Bentil had to conduct her work remotely from Ames instead of at Edwards Air Force Base in California.

Bentil's summer research was overseen by Timothy C. Miller, senior materials research engineer with AFRL's Aerospace Systems Directorate. Miller sought to work with someone who could perform experiments that would apply high-speed loads to solid rocket propellants, and Bentil saw an opportunity to assist in this work using her oxyacetylene shock tube to apply a mechanical load on the surface of the solid rocket propellants. Solid rocket propellants are used as fuel in military applications to generate thrust for tactical or strategic rockets and missiles.

"My objective of the experiments was to understand how the solid rocket propellants responded to tensile loads at speeds that are at least on the order of what the propellants will encounter during the ignition and firing process," said Bentil. "That's because those loading speeds are when damage to the solid rocket propellant occurs, which manifests as cracks in the material that will negatively impact the ballistic performance."

By understanding the conditions that will create these cracks, Bentil said the results of her experiments would help AFRL in optimizing the ingredients in the solid rocket propellant to eliminate crack formation. Additionally, these findings would also help AFRL in designing health-monitoring sensors that can predict the behavior of the solid rocket propellant given the percentage of damage.

Bentil creatively adapted her project to the constraints of the pandemic. She conducted most of the research in her The Bentil Group lab on the Iowa State University campus. She did not have the opportunity to participate in the process of making solid rocket propellants and instead relied on Miller, her advisor with AFRL, to ship them to her from California. California's stay-at-home order prevented Bentil from working with a wide array of solid rocket propellant samples since members of Miller's team were not permitted in the lab to fabricate additional samples. However, despite these adjustments, Bentil was still able to make the best of the experience.

"Working remotely did allow me to begin developing computational models that would be validated using the results from the shock tube experiments," said Bentil, adding that computational models would be used in improving damage predictions in the solid rocket propellant.

"I wanted to pursue this computational aspect in the future. However, working remotely and not being able to perform the other experiments using AFRL's equipment, allowed me to start developing the computational aspect of the project over the summer," she said.

Bentil utilized various ME concepts and methods throughout her summer research. She and her team utilized Newton's laws of motion, work-energy principles and vibrations, as taught in ME 345: Engineering Dynamics, as well as data acquisition systems, analysis of data and propagation of measurement uncertainty taught in ME 370: Engineering Measurements. The researchers also utilized stress-strain relationships, elements of material behavior, continuum mechanics and finite element analysis.

The research that Bentil conducted over the summer was mostly new to her as much of her past work has focused on soft tissue (e.g. brain). However, she said she sees similarities between the brain tissue and solid rocket propellants in the sense that both materials are considered "viscoelastic."

"Viscoelastic means that the material is not a solid and it's not a liquid. Rather, the viscoelastic material is somewhere between a solid and a liquid. Even though the brain and solid rocket propellant are both viscoelastic, working with the propellant was a lot easier, and not as messy as the brain," Bentil said.

Going forward, Bentil said she would like to conduct more experiments that will facilitate the prediction of damage in other viscoelastic materials due to loads that are applied at high rates. Aside from some of the direct research knowledge she gained through her participation in the SFFP, Bentil said one of her biggest takeaways from this experience is the potential for future collaborations with AFRL.

"I look forward to future collaborations with AFRL, where Iowa State University students from my lab can also participate in the experiments and computational modeling needed to predict damage in solid rocket propellants and other viscoelastic materials," Bentil said.

Summer program opened door to nuclear industry for alum

While some high school students attend summer camp to enjoy the great outdoors, one Iowa State University alum attended a different kind of summer camp to learn about nuclear engineering and it ended up having a profound impact on her professional development.

Lora Drenth grew up on a farm in northwest Iowa. As a junior at Rock Rapids High School she began developing an interest in nuclear engineering (NE), and this interest became the focus of an essay she drafted when applying for a summer academic program at Iowa State University. Drenth was admitted into the program (for which she received college credit and had the opportunity to live in the dorms) and was placed into the NE tract.

"It was my experience with the faculty in the department during this summer program that helped me to decide to enter the nuclear engineering program at Iowa State," Drenth said, adding that all but one of her five siblings pursued STEM degrees at Iowa State, which further influenced her decision to come to Ames.

She declared a NE major shortly after arriving on campus as an official student and found that because of the relatively small department size, she was able to interact directly with many of the department's faculty. Drenth became close with **Richard Danofsky** through her involvement with the student chapter of the American Nuclear Society, of which she served one year as president. She also fondly remembers **Bernard Spinrad** who served as chair of the NE department.

As a collegian, Drenth was also involved with the campus horseback riding club and Tau Beta Pi, for which she led the singing during the initiation rituals. She developed friendships with her classmates and dorm-mates from the now-defunct Westgate Hall, which once stood west of where the Thielen Student Health Center stands today, and remembers the good times they had when they would eat meals together.

"Pizza and ramen sure were cheap back then," she said with a laugh

After completing her undergraduate studies, Drenth took graduate-level courses in NE at Iowa State but she did not end up completing the degree for her program. Instead, she entered the workforce after landing a position with Northern States Power (now called Xcel Energy) in Minneapolis.

"Three of my classmates had gotten jobs there, and since I was tired of being a poor graduate student, I was happy to join them," said Drenth, adding that it was classmates she met at Iowa State who told her about the opportunity with Northern States Power.

Drenth said she began applying the concepts and methods she learned from Iowa State's NE curriculum almost immediately, even though she admits that while initially taking some of those courses she questioned when she would actually use that material in a real-world situation.

"Prior to widespread use of personal computers and word processing, we wrote down our engineering calculations by hand. So, the course on engineering drawing and writing was obviously useful," she said.

She spent the first four years of her career doing nuclear analysis and core design for Prairie Island, located in downtown Minneapolis. She eventually moved on to working on ventilation systems for the plant, before taking a brief hiatus in the early 2000s to raise her children full time. She returned to Xcel in 2006 and her new duties involved evaluating boric acid corrosion and metal fatigue, and later analysis and inspection of the internal components of reactor vessels. Her current work responsibilities focus on reactor vessel embrittlement and steam generator inspections.

Throughout her career, she said she often applied material she learned back at Iowa State, such as calculations of reactivity, control rod worth, shutdown margin, and temperature coefficients. She said concepts from courses such as heat transfer, fluid mechanics and thermodynamics proved to be useful when pursuing her Professional Engineering license earlier in her career.

Reflecting back on it, Drenth cites meeting a finance major named Malcolm Polley, her former husband, as her most memorable moment from her time on campus.

"Most of my fondest memories from Iowa State are the time spent with him," said Drenth. "I remember going to dorm parties, dances at the MU, concerts at Hilton and Cyclone football games together."

Lora currently lives on a 15-acre hobby farm about an hour outside of Minneapolis with her three horses. She jokes that she grew up just south of Ellsworth, Minn. and now she lives a few miles south of Ellsworth, Wisc. Her son Karl Polley has his architecture degree from Iowa State and currently lives in St. Paul, while daughter Morgan Williams works in public relations in Philadelphia. In December 2019, Morgan gave birth to Aldo, Lora's first and (so far) only grandchild. In her free time, Lora enjoys gardening and researching her family genealogy, but she never forgets about the strong bond she developed with her alma mater.

"Iowa State taught me the value of applying myself to reach a goal. It started with writing the essay and being awarded the opportunity to begin my studies at ISU. Focusing on the classes I needed to graduate allowed me to complete my B.S. in three years. When necessary, that ability to identify and focus on reaching a specific goal has carried through to several projects I have worked on during my career," she said.

Pandemic impacts ME student's graduate school selection process

It took a pandemic and the inability to do on-campus visits that led one mechanical engineering student to decide he wanted to stay a little closer to home for graduate school.

Antonio Alvarez-Valdivia

Antonio Alvarez-Valdivia originally wanted to leave the Midwest for graduate school when he completed his B.S. in mechanical engineering (ME) in Spring 2021. However, because of the COVID-19 pandemic many of his campus visits were conducted virtually and this caused him to rethink his priorities for what he wanted in a graduate school program.

"I was excited about moving to a big city on the East or West coasts," said Alvarez-Valdivia. "However, these hard times made me realize it was important for me to stay somewhat close to home, so choosing a program around the Midwest became an essential factor in my decision-making."

Alvarez-Valdivia, who has yet to make his decision, added that finding a program that aligns with his research interest of soft/flexible robotics and electronics for biomedical applications and wearable devices is the most important factor he is considering when selecting a grad program. Even though the pandemic has made it harder to visit different campuses, he said it has been easier communicating with faculty at his prospective schools via video conferencing and phone calls.

Alvarez-Valdivia is originally from Guadalajara, Mexico. His teachers in middle school encouraged him to pursue studies in STEM and he had the opportunity to attend a vocational high school program that specialized in automation and instrumentation. For college, he chose to attend Iowa State University because of its strong reputation for engineering and picked ME as his major because of its versatility.

"From thermodynamics and heat transfer to system dynamics and controls, I believe ME would provide me with extensive training to become a great engineer," he said, adding that ME 335: Measurements and Instrumentation and ME 421: System Dynamics and Control have been among his favorite courses he's taken.

Alvarez-Valdivia also does research in the lab of **Jaime Juárez**, assistant professor of ME. Not only has this given Alvarez-Valdivia hands-on research experience, but he's also developed a close mentor-mentee relationship with Juárez.

"Dr. Jaime Juárez has been a great mentor, and I really appreciate all the wisdom he has shared with me over my undergraduate education," said Alvarez-Valdivia. "He provided me with educational experiences that I could not have gotten in any other way."

Alvarez-Valdivia has also participated in the combat robotics team (part of the ISU Robotics Club) and works as a peer mentor for Engineering Student Services, helping students who transfer into engineering at Iowa State. In 2019, he served as a summer research intern in the SUNFEST REU Program at the University of Pennsylvania in Philadelphia.

On top of everything, Alvarez-Valdivia is also part of the McNair Program at Iowa State, which he considers "one of the most impactful experiences of my life." The program is designed to prepare underrepresented minorities and first-generation undergrads for graduate school.

"In addition to being provided with academic research training, application preparation, and personal and professional development, I was also introduced to a great and diverse community of scholars that have become my family," he said.

In his free time, Alvarez-Valdivia enjoys cooking and gardening. In addition to preparing traditional Mexican family dishes, he also enjoys experimenting with different cuisines from other parts of the world. He currently has about 15 indoor plants and more than ten different hot pepper plants. During the warm months, he maintains an outdoor garden with cucumbers, zucchinis, corn and radishes.

Pursuing a Ph.D. in ME will be Alvarez-Valdivia's next step after he graduates from Iowa State. After completing his Ph.D., he will decide if he wants to enter the field of academia as a professor or if he would be a researcher for either a national lab or a private company. As his time at Iowa State University comes to a close, Alvarez-Valdivia reflects and offers some advice to incoming students.

"I would say that it is important to think about your professional goals at the early stages of your undergrad journey. If you want to become an engineer in a specific industry, push yourself to get an internship as soon as you can, and if you want to go to grad school, definitely explore the research opportunities available," he said.

"Another thing I recommend is to become friends with people outside engineering, as it will help you think outside the box. Having a diverse group of friends, both academically and culturally, has been an enriching experience for me."

Undergraduate research experience launches ME student to NASA internship

As someone who benefited greatly from the encouragement she received to pursue studies in STEM, mechanical engineering senior Olivia Tyrrell wants other girls and women to also be inspired to go into STEM.

Tyrrell grew up in Downers Grove, Ill. Though she always had an interest in science as a child, it was a visit to Argonne National Lab for Women in Science Day led by her high school physics teacher that sparked her interest to pursue engineering in college.

She picked Iowa State University because of its strong reputation for engineering as well as the scholarship support she was awarded. She said she was also attracted to the campus and its "big university feel." Though she came in undeclared in engineering, she soon found her niche in mechanical engineering (ME).

"I ultimately chose ME because I was interested in potentially working in the healthcare field on medical devices," said Tyrrell. "It seemed like ME would cater more to my diverse interests and I felt more secure knowing that I could go into nearly any sort of technical industry with that degree."

Tyrrell further developed her diverse interests through participation in a handful of engineering activities on-campus. She has been part of the Biomedical Engineering Society for the past three years and currently serves as the club's vice president. As a sophomore, she served as a learning community peer mentor for Women in Science and Engineering (WiSE). Music is also an important part of Tyrrell's life. She's played alto saxophone in Iowa State's jazz ensembles since she arrived on campus. She considers music to be a stress reliever and a nice break from the rigors of the ME curriculum.

As a junior, she got involved with research and joined the Multiphase Reacting Flow Lab, working under the guidance of **James Michael**, assistant professor of ME. Tyrrell took ME 332: Engineering Thermodynamics II with Michael, and said she's applied material from that course and others in her research.

"The exposure to research at a graduate level and the strengthening of my technical reading, writing, diagnostics and data processing skills has been extremely beneficial. By giving me the opportunity to work collaboratively and independently on a research topic, Dr. Michael has introduced me to a lot of opportunities for research in the future," said Tyrrell, adding that she thinks the research experience helped her to land her current internship with NASA.

The internship started in January and will conclude in August. Though the internship is through NASA's Langley Research Center (located just north of Norfolk, Va.), Tyrrell has worked remotely from her university apartment in Ames. The internship is with Langley's Advanced Measurement and Data Systems branch, and much of her work focuses

Olivia Tyrrell

on experimental visualization and simulation of research taking place in Langley's wind tunnels, some of which can reach speeds of Mach 10 (10 times the speed of sound).

Through her internship she has also contributed to the Commercial Lunar Payload Services program by providing visualization of imaging systems that will go to the Moon in 2021 and 2023 as part of a payload called SCALPSS (Stereo Cameras for Lunar Plume Surface Studies). She said the knowledge and skills she's developed through her courses in fluid mechanics, heat transfer, CAD and Matlab have been useful throughout her internship experience.

Tyrrell was featured in an article published on NASA's website which highlighted some of NASA's Langley interns as part of Women's History Month. Encouraging more women and girls to pursue studies and careers in STEM is one of Tyrrell's passions.

"I think it's terrific that more young women are pursuing careers in STEM and I'm definitely an advocate for making the field more diverse as a whole," said Tyrrell. "Providing encouragement and positive opportunities for people who have historically not been represented in the field can only lead to more success and innovation, in my view."

Tyrrell will complete her B.S. in ME in Fall 2021. She has yet to decide what she will do for the next chapter of her life, but she knows that whatever it is her time at Iowa State has prepared her well for it.

"I'm hoping to return to NASA as an engineer but am also considering graduate school to continue my education and stay involved in research. I'm really happy to have a lot of different options and paths to be considering right now and I attribute that to the great job that Iowa State has done preparing me to be an effective engineer," she said.

Transfer graduate student finds new home at Iowa State

Going from a smaller university in an urban area to a larger university in a smaller college town might have been difficult for some, but for mechanical engineering graduate student Murtaza "Murt" Zohair the transition was smooth.

Zohair is from Aurora, Ill., part of the greater Chicago area. Growing up he was often reading books as well as science magazines and had the opportunity to visit the museums in the Chicago area, particularly the Museum of Science and Industry.

"I remember science exhibits and demos that were sometimes related to the things I'd read," said Zohair. "That started my interest in science, and it carried forward as I went through school."

For his undergraduate studies, Zohair attended the University of Illinois at Urbana-Champaign with the intention of majoring in biology but found that he was more interested in his courses pertaining to materials science and engineering (MSE). This, coupled with the research opportunities available in MSE, led Zohair to switch majors. He completed his B.S. in MSE in 2018 and then went to Vanderbilt University to pursue a Ph.D. in interdiscplinary materials science.

At Vanderbilt, he worked in the lab of mechanical engineering faculty member **Cary Pint**. But when Pint accepted a position on the ME faculty at Iowa State in Spring 2020, Zohair had to decide if he'd stay in Nashville or if he would follow Pint to Ames. He chose the latter and attributed his reasoning to Iowa State's strong reputation for engineering, coupled with the connection he developed with Pint, who serves as the Charles Schafer (Battelle) Chair of Engineering at Iowa State, as his mentor.

"Dr. Pint has an infectious passion for the work we do and is personally invested in the success of his students. That, along with being a little closer to home, made moving the right decision for me," Zohair said.

Murt Zohair

Zohair observed that it was interesting going from big city of approximately 670,000 inhabitants to a college town roughly a tenth that size. The two universities are also very different in size with Vanberbilt having an enrollment of roughly 13,500, 6480 of whom are graduate and professional students, compared to Iowa State's enrollment of nearly 32,000, 4979 of whom are graduate and professional. (Based on 2020-21 enrollment figures.)

"There is a small-town sense of community that I've gotten from everyone I've interacted with at ISU which is unique for a big school," he said, adding that he enjoyed his experience at Vanderbilt and has fond memories from his time there.

At Iowa State, much of Zohair's research in Pint's ENERG @ ISU Lab focuses on characterizing the failure and decay of batteries. One of his projects involves building nanomaterial-based sensors into existing battery structures so that the energy density of the cell is not compromised. Another project involves electrochemical synthesis of nanomaterials and designing interfaces in energy devices.

Outside of the lab, Zohair loyally follows his hometown sports teams, particularly the Chicago Bears and Chicago Bulls. He also enjoys watching movies and TV shows, *Judas and the Black Messiah* and *The Queen's Gambit* being a couple of his favorites. During quarantine he has experimented with baking and is currently on a kick making his own sourdough bread. He said he appreciates that the research labs and other campus facilities such as the rec center have been able to re-open with modifications, which he said "brings back some sense of normalcy while still prioritizing safety" during this era of COVID-19.

Zohair plans to complete his Ph.D. in 2022 and hopes to continue working on materials for energy applications in industry or at a government lab after graduation.

ME's Charlie Kohler named Wallace E. Barron All-University Senior Award recipient

Charles Kolar ('20 mech engr) has been named a recipient of the ISU Alumni Association's Wallace E. Barron All-University Senior Award. The award honors outstanding seniors who display high character, outstanding achievement in academics and university/community activities, and promise for continuing these exemplary qualities as alumni.

If there is one thing you can say about Charles Kolar, it is that he never lets an opportunity go to waste.

Charlie is a student-athlete at Iowa State University, balancing a heavy class load in mechanical engineering while training to crush opponents on the football field as one of Iowa State's most prolific tight ends in the program's history. The son of two professors, Charlie will "do whatever it takes to earn the

Continued on page 13

ME advisors develop platform for students to interact virtually

Iowa State University's mechanical engineering advising team has developed a virtual space that they hope will serve as a way for students to connect with one another during an era of social distancing and remote learning.

Mindy Heggen, mechanical engineering (ME) academic advisor, came up with the idea of creating a group using Microsoft Teams, a software program designed for groups of people to collaborate remotely on projects. Heggen called the group "Like ME" and it was developed specifically for undergraduate ME students.

Mindy Heggen

"The Like ME Teams was created to offer a space for students to connect socially with the department and connect with others in the same courses to set up study groups," Heggen said.

The idea first came about when the COVID-19 pandemic caused university personnel to adapt classes and other operations so that adequate social distancing can be maintained between individuals to prevent further spread of the virus. Heggen felt that a virtual space, such as Teams, might help to emulate the regular, face-to-face interactions that students would have during a typical school year. For students who can struggle with face-to-face interactions or even just meeting other people, this digital environment can be an easier way for them to connect with peers they might not otherwise meet. She cited research which suggests that greater social connectivity can lead to academic success as another reason for establishing this group.

Like ME is intended to not only be an educational tool but also a social one, as a way for students to connect on common interests outside of the classroom. Team members have access to Jackbox which allows them to play a vast library of video games with one another. Additionally, some members participated in a fantasy football league during the fall semester. The group is free to join for all undergraduate ME students.

Heggen said that finding the time to develop the group, while balancing all of her other work responsibilities, was one of the biggest obstacles she encountered along the way. To alleviate this, a student peer mentor has been assigned to manage the social piece of the group during the spring semester.

Students have provided positive feedback about their experience in the group. Heggen cited that some students were able to raise their midterm grades because of the academic support they received from their peers through the group. She said she's also heard from students outside of ME who have indicated they think a similar platform within their major department would be helpful. She presented her idea to other advisors in the College of Engineering with the hope they might develop a similar platform for their department.

"Our advising team's creativity never ceases to amaze me," said Caroline Hayes, ME department chair and Lynn Gleason Professor of Interdisciplinary Engineering. "It is so important for our students' success and well-being to safely connect with their classmates. I think Like ME will be helpful to students even after we can all safely gather in-person again."

Based on the success of the initial roll out, Heggen and the rest of the advising team echo Hayes' sentiment that Like ME might continue to be a worthwhile tool for the students even in a post-COVID-19 world.

"It is a unique way to meet students where they are physically. In the cold winter and rainy spring, they can meet virtually to play games that they enjoy, such as Among Us. It will help with staying socially connected over breaks, summer, co-ops and internships," Heggen said.

perfect score" according to one of his nominators. These words are true both on the field and in the classroom.

Charlie has earned many recognitions, including First Team All-Big 12 honors and All-American honors, and he is a National Merit Scholar. When he is not playing football, studying, or sleeping (of which he does little), you can find Charlie visiting Mary Greeley Hospital to volunteer or reading to children at a local elementary school. This volunteerism has extended to various projects throughout Charlie's time on campus, including Marshalltown tornado relief, service with Victory Day and ExerCYse Time, and more. He is active in undergraduate real-world research, demonstrating the Iowa State innovative spirit, and is a member of the Student Athlete Advisory Committee (SAAC).

In short, Charlie has a great love for Iowa State and the opportunities that it represents for both himself and Cyclones everywhere. As another one of his nominators wrote, "He shows up with incredible energy every day to make himself and his fellow teammates and classmates better."

Contributed by ISU Alumni Association

Photo courtesy of Iowa State Athletics Communications

Engineer by day, brewer by night

When he's not busy conducting research in the laboratories of the Bioeconomy Institute on the Iowa State University campus, **Robert C. Brown** might be found working in another lab he has inside his home. This one happens to be a brew lab.

Brown, a distinguished professor in mechanical engineering and director of Iowa State University's Bioeconomy Institute, is among the roughly 1.2 million Americans who brew their own beer. Brown said that he came of age before the craft brewing revolution and had little interest in the traditional lagers (Budweiser, Coors, Miller, etc.) that dominated the beer market at the time.

Robert C. Brown poses in the brew lab that he has set up in the basement of his home.

Being an experimentalist, Brown decided not to strictly adhere to the ancient German beer purity law of "Reinheitsgebot" which decrees only four ingredients be used in beer brewing – barley malt, hops, water and yeast – when he began brewing his own beer.

"With respect to the Reinheitsgebot, I am a scofflaw, frequently employing oats, wheat, rye, fruit, brown sugar, spices, peppers, chocolate and even bacteria in my brewing," said Brown, who also serves as Anson Marston Distinguished Professor in Engineering and Gary and Donna Hoover Chair in Mechanical Engineering at Iowa State.

A family matter

For Brown, homebrewing is a family matter. It was his three sons who first introduced him to craft beer roughly 12 years ago. Brown said that he was "pleasantly surprised" with the variations he tried and was intrigued by the fact that some of these variations had been in existence for a century or longer, prior to making a resurgence in the United States with the craft beer revolution over the past couple decades.

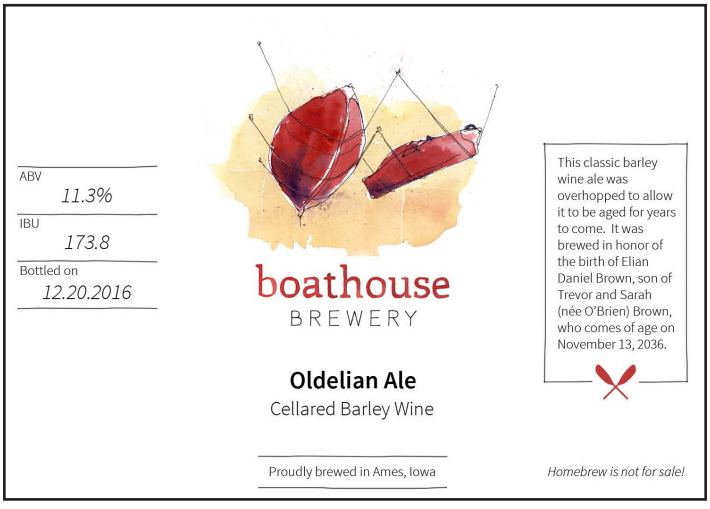
After a couple years of enjoying craft beers, Brown and his sons decided to take the next logical step and began brewing their own beer.

"For a while, my wife tolerated us in the kitchen but today I have a dedicated brew room in the basement with a gas stove top, utility sink and three freezers with temperature controllers used in fermenting, lagering and dispensing beer," Brown said.

Brown's middle son, Trevor, a trained artist, designs the labels for the beer they brew. These labels include original artwork created by Trevor as well as details about the beer and even a clever description for each brew. Upon the suggestion of his eldest son, Tristan, Brown brews a batch of strong ale for cellaring upon the birth of each grandchild. The adults in the family open a bomber (22-oz bottle) each year with the last bottle timed to be opened when each grandchild comes of age. To survive the cellaring process, these brews have exceptionally high alcohol by volume (ABV) percentages. Brown currently has four grandchildren and a unique brew for each of them.

The beer brewing process

Brown said he spends at least six hours when preparing an "all grain" five-gallon batch using malted grains. This includes grinding the grains; mashing them to produce a sugary wort; boiling, hopping, and cooling the wort; filling and aerating a fermenter; pitching yeast or blends of microorganisms into the



Right: *The label for Brown's Oldelian Ale, a cellared barley wine brewed in commemoration of the birth of Brown's first grandchild, Elian Daniel Brown. Graphic courtesy of Trevor Brown.*

wort; and cleaning up. He added that there is some prep he does the day before he starts a new batch, which involves adjusting mineral content of the brew water and making a yeast starter.

Small batches using malt extract eliminates the grain mashing step and can be completed in less than half the time. However, the final fermentation step takes anywhere from one week to over a year before the beer is ready to drink, depending upon the choice of microorganisms and the style of beer.

The process differs depending on the type of beer he's brewing. Beer brewing roughly breaks down into room temperature fermentation with "top fermenting yeasts" to produce ales and cool fermentations with "bottom fermenting" yeast to produce lagers, according to Brown. He has recently begun experimenting with "hot fermenting" yeast at temperatures approaching 90 degrees Fahrenheit, which speeds the conversion of sugar to ethanol without compromising product quality.

"Part of the fun of brewing is exploring new combinations of ingredients. For example, this past summer I concocted a jalapeno sour ale, which is initially fermented with lactobacillus, the same bacteria used to make yogurt, in a wort boiled with fresh jalapenos," Brown said, adding that he also brews the more familiar and easy drinking beers like pilsners and wits.

"In the corner of my basement brew room is a glass carboy of slowly fermenting beer that is home to wild microorganisms that had contaminated one of my conventional beers years ago but are now harnessed to produce a Lambic-like beer," said Brown.

For those looking to pursue their own adventures in homebrewing, Brown offers some advice. First he said it can be helpful to befriend a veteran homebrewer willing to show a rookie the ropes. Alternatively, he said, John Palmer's book *How to Brew* is an effective guide for the novice homebrewer. A large kitchen pot can serve as a brew kettle and most of the other necessary equipment can be purchased for less than $50. Raw ingredients for a five-gallon batch range from $25 to $50.

Parallels to engineering research

Prior to the advent of technology like thermometers, hydrometers, and precision weight scales, Brown, who has academic appointments in mechanical, chemical and biological, and agricultural and biosystems engineering, said brewers often approached brewing as an art rather than a scientific process.

Save the Date!

Dr. Brown in partnership with the **Center for Crops Utilization Research** at Iowa State University plan to offer a homebrewing workshop later this year. Organizers hope to have a syllabus developed and the necessary equipment purchased so the workshop can be offered in **the fall**.

For more info about this event, contact ***Jordan Funkhouser*** *at* ***jfunk@iastate.edu***

He thinks engineers can apply techniques and knowledge from their field to improve the homebrewing process.

"I see misperceptions among the homebrew community ranging from how long it takes to drive-off sulfur compounds while boiling lager wort to the role of nitrogen in producing the creamy colloidal foam of beer on nitro," Brown said.

Brown said that the parallels between homebrewing and his particular research, is "closer than you might think." Successful homebrewing involves the conversion of starch polymers in grains into simple sugars to form a fermentable solution, while Brown's research in bioenergy focuses on the conversion of cellulose polymers in biomass into simple sugars to form a fermentable solution.

"I have brewed dozens of beers at home from starch-derived sugars but so far only one beer from biomass-derived sugars produced on campus, which I am afraid was not drinkable," said Brown. "But the same could be said of my first homebrewed beer. On more than one occasion, a weekend of homebrewing has inspired ideas for my research on campus."

Last year Brown was awarded a multimillion dollar grant from the Defense Advanced Research Projects Agency (DARPA) to develop a system to convert plastic and paper wastes generated by the military into macronutrients to feed expeditionary forces. Brown and his team are using a thermal process to convert these wastes into substrate for fermentation into single cell protein. The team not only has to prove out the basic concept, but they eventually need to build a field deployable fermentation system that is simple enough for soldiers to operate.

"The constraints to this problem have several parallels to homebrewing. As I told our team, I have been preparing for this project for the last ten years," Brown said.

Left: *Robert C. Brown's home brew lab system. The stainless steel pots on the stove top are used to mash grains and boil wort. The pump attached to the bench circulates wort during mashing and a heat exchanger is used to cool the boiled wort as it is pumped into a fermenter (not illustrated). To the left are some of the specialty grains used to make different kinds of beers. The glass carboy on the right holds a "wild beer" that has been aging for over a year.*

Engineering and the art of communication

Margaret Harding

It can be challenging to understand technologies that most of us don't interact with routinely. They can be complex, arcane and hard to access in our time-constricted lives. Yet, as the recent Texas energy debacle demonstrates, it's important. One Iowa State University alum has made a career of making an important energy technology – nuclear energy – more accessible to the public.

Growing up in Mason City, Iowa, Margaret Harding took a liking to math and science from an early age. Her parents would often leave books around the house as a way to encourage her to read, but instead of gravitating toward the classic novels, she found herself more interested in books involving numbers.

"One of the books my parents left out was about prime numbers and after reading it I was like 'wow, this is cool,'" she said with a laugh.

Harding took all of the chemistry, physics and advanced math courses offered at Mason City High School. Though she briefly considered majoring in astronomy at the University of Iowa with the desire to study under renowned physicist James Van Allen, she ultimately decided to stay a little closer to home and came to Iowa State University to study applied mathematics, thinking she might become a math teacher.

However, as news about everything from carbon pollution to oil embargoes dominated the headlines during the late 1970s, Harding began developing an interest in the energy sector. This interest had a profound impact on her eventual career trajectory and she ended up switching her major to nuclear engineering (NE).

Even though the NE undergraduate program was relatively new (Harding was part of the second graduating class), nuclear-related research at Iowa State traced its origins back to the 1940s and the university's role the Manhattan Project. A formal graduate program in NE was established in 1950, and by the end of that decade; the university's teaching reactor went into operation in the Nuclear Engineering Building (where the Student Innovation Center stands today).

In the curriculum, Harding learned the technical knowledge necessary to be a successful engineer. She took the theory and other concepts from her coursework. She was able to see how it applied in a practical matter, noting that seeing it in practice in the reactor helped her to conceptualize her learning.

But it wasn't just the technical knowledge itself that Harding remembers. She said the department's emphasis on other skills such as problem solving and effective communication proved to be invaluable throughout her career. In particular, she remembers the required speech and technical communications courses.

"Communication skills are important for engineering, because if you can't effectively communicate a good idea, it can be difficult for others to understand why it matters," she said.

Harding was also busy outside of the classroom. One of her fondest memories was having the opportunity to play the carillon, the keyboard-like instrument housed inside of Iowa State's iconic campanile.

Continued on page 17

Right: *The basic layout of the carillon is similar to a piano, except instead of keys the instrument consists of rods.*

Continued from page 16

"During my freshman year, the carillonneur at that time would leave the door open and you could go up and watch him play," said Harding. "After watching him play, he taught us how to play."

Being from Mason City, home to the famous composer Meredith Wilson, Harding got involved with music at an early age so she picked up the basics of the carillon relatively quickly. Just because no college experience would be complete without a little tomfoolery, she recalled sneaking up into the campanile before midnight to add extra rings during a mass "campaniling" around homecoming.

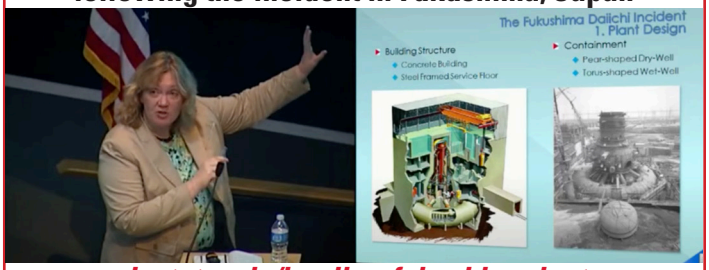
Harding completed her B.S. in NE in 1981, becoming the first female to complete the degree, and she started working for the Nuclear Engineering division of General Electric (GE). She spent nearly three decades with the company, working her way up to be vice president of engineering quality for GE-Hitachi Nuclear Energy. Throughout her career, she worked alongside many other NE graduates from Iowa State, often reminiscing about their favorite professors and other memories from their time in Ames.

In 2008, Harding left GE and the following year she started her own company, 4 Factor Consulting, LLC. She said this work allows her to combine her technical, problem solving and communications skills with her knowledge of the regulatory and business sides of the nuclear industry. She works with large government and corporate clients as well as small start-ups to leverage these skills for a variety of issues.

Harding has also served on advisory boards for WizNucleus as well as Iowa State's College of Engineering. She returned to Ames in April 2011 to present a lecture on the Fukushima Daiichi incident. During the days following the incident, she became a reliable source for many journalists as they pieced together information regarding the before and the after of the tragic event that occurred on March 11, 2011. When talking to media, she always focused on factual accuracy and steered clear of sensationalism, despite some reporters asking leading questions.

"The thing all those journalists learned was that I was a no speculation zone," said Harding. "Some journalists might have a slant, but I think most just want to get accurate info out to the public."

Watch Harding's 2011 lecture, following the incident in Fukushima, Japan



me.iastate.edu/harding-fukushima-lecture

Harding said that using relatable analogies were often effective when relaying complicated nuclear matters to reporters. She would go on to receive the Presidential Citation from the American Nuclear Society for her role in communicating information to the public during the aftermath of the Fukushima incident.

Outside of her consulting work, Harding also developed and taught Nuclear Energy in Society at Iowa State University. She said she appreciated the opportunity to return to her alma mater and to educate the next generation of engineers about the nuclear industry.

"I would always tell my students I was usually speaking English but occasionally speak jargon without realizing it, so stop me if I do," she said, adding that she always encouraged students to ask questions, even relatively simple ones, knowing that someone else in the class might have the same question but be too bashful to ask.

In her free time, Harding stays busy with her two miniature dachshunds: Woodstock, named for the village in Vermont; and Parry, short for paradox. She also enjoys baking. Lately she has been experimenting with different varieties of French-style macarons, a cream-filled, cookie-like dessert. A couple of her proudest concoctions include an orange creamsicle macaron, a king-cake macaron, and a tiramisu macaron. She has also invented a chocolate mole cookie with pumpkin seeds. Ever the engineer, she appreciates the parallels between baking and foundational engineering courses like chemistry.

"People don't realize how creative engineers really are," said Harding. "Engineering has a huge creative streak so to me baking makes perfect sense."

A course description for Nuclear Energy and Society from the 2013-14 Iowa State University course catalog.

NUC E 430. Nuclear Energy and Society.
(3-0) Cr. 3. Alt. S., offered 2012. *Prereq: NUC E 401*
The relationship between nuclear energy and society is examined from the perspective of significant events in the commercial nuclear power industry. Event analysis includes differences and similarities of technologies along with environmental impact. Political, social, media and regulatory responses for each event are discussed along with the impact on future plant design. Nonmajor graduate credit.

Applying mechanical engineering to pharmaceutical research

Conducting research within the field of pharmaceuticals might be the last place you'd expect to find a mechanical engineer but **Michael Olsen** would prove you wrong.

Olsen, a professor of mechanical engineering (ME) at Iowa State University, is getting ready to begin his newest research project with his colleague Dennis Vigil, professor of chemical and biological engineering at Iowa State, for the pharmaceutical company Pfizer. For this newest project, Olsen, Vigil, and their research team will develop a computer model to assist Pfizer in predicting the behavior of ointment creams under the various manufacturing processes that they undergo, from emulsification in a homogenizer, to transport through pipes and valves in the manufacturing plant, to the packaging process.

"To assist in the development of this model, we will use data obtained by Pfizer on droplet size and population during homogenization as well as data that we will collect in our laboratory for droplet coalescence using a Taylor-Couette reactor," said Olsen, who is also a researcher with Iowa State's Center for Multiphase Flow Research and Education.

Olsen and Vigil will utilize various ME concepts and methods in this project including fundamental thermal sciences (fluid mechanics, thermodynamics, heat transfer), computer programming and manufacturing. This project will showcase the diversity of an ME's skill set, according to Olsen. First, he said, it highlights the importance of the fundamental thermal sciences beyond what are viewed as the "traditional" areas of mechanical engineering (i.e. HVAC, heat exchangers, combustion, refrigeration).

"The fundamental thermal sciences are very important in the biomedical arena, such as pharmaceutical manufacturing, as in this project, medical device design for say artificial heart valves or ventilators, and even physiological processes in the human body, like blood flow and respiration," said Olsen, adding that the project will help his ME students to understand how they might collaborate with chemical engineers, biomedical engineers and researchers from other fields in the future.

Olsen and Vigil's research partnership with Pfizer first started about three years ago when Avik Sarkar, a scientist from Pfizer, visited the Iowa State University campus. Sarkar toured their lab and was interested in the multiphase flow research that Olsen and Vigil were conducting, specifically focused on Taylor-Couette flow. Sarkar realized that the work the Iowa State researchers were doing could be adapted to investigate the emulsions that make up topical ointment creams.

Michael Olsen

For their first collaboration the researchers investigated the effects of strain rate and temperature on phase separation in a petrolatum based topical ointment cream. The ointment consisted primarily of petrolatum (the main component in Vasoline) and polyproline glycol droplets that contain the pharmaceutical agent. Pfizer wanted to know about the conditions under which this emulsion would break down into its individual components, a phenomenon known as phase separation, rendering the ointment useless, according to Olsen.

"We designed a temperature-controlled Taylor-Couette flow cell that would allow us to carefully control the strain rate and temperature imparted on the ointment and developed imaging techniques to visualize the onset of phase separation," Olsen said.

Taylor-Couette flow is the flow generated in the annulus between two concentric cylinders when one or both of the cylinders are rotated. In their experiments, the inner cylinder was rotated.

"Because the Taylor-Couette reactor that we constructed has a very narrow annulus between the cylinders, the resulting flow has a nearly uniform shear strain rate, allowing us to easily investigate the effect of strain rate on the phase separation," said Olsen. "From these experiments, we were able to determine the conditions under which the ointment was in danger of undergoing phase separation."

In a second project, Iowa State and Pfizer utilized some of the same techniques they used in their first experiment to study phase separation in a mineral oil-based ointment. The success of these first two projects is what led them to come together for this newest effort. Olsen also acknowledged the work of two of his former graduate students, Hannan Nadeem and Arya Haghighat, for their contributions to these efforts.

The experimental and modelling techniques that the researchers are developing for this project could eventually be extended to other ointment formulations. Olsen said they might also apply the computer model they developed to future projects to perform droplet breakup and coalescence measurements at constant temperatures and strain rates in a Taylor-Couette reactor designed explicitly for this purpose.

Mechanical engineering researchers develop new approach for additive manufacturing

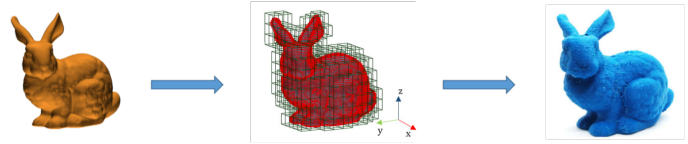
A team of mechanical engineering researchers at Iowa State University have developed what they hope can become a new, more efficient method for 3D printing of complex CAD models.

Adarsh Krishnamurthy, associate professor of mechanical engineering (ME), is leading the effort with support from ME students Sambit Ghadai and Anushrut Jignasu. The findings from their research were published online February 25 in the journal *Additive Manufacturing*, the third highest-rated engineering journal according to Scopus.

The researchers proposed a new method for 3D printing directly using voxels. This differs from traditional FDM (fused deposition modeling) 3D printing methods which use triangulated models (via STL files) that need to be sliced before being printed. This new approach also works for large volumetric data, like MRI and CT scans, where they can directly print the model. The researchers also generate print directives, called "G-code," which is then sent to the printer to directly print the model.

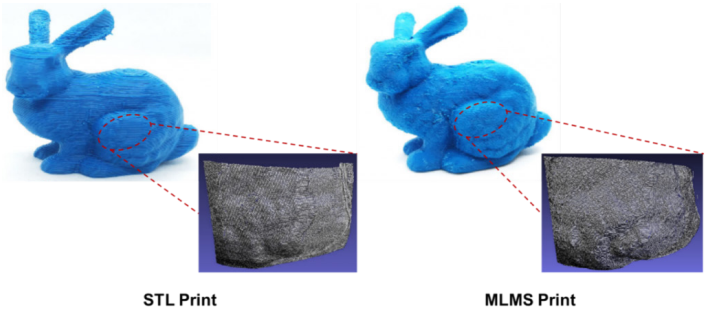
"One of the advantages of this method is that the surface quality of printed models is equivalent and in some cases better than the traditional STL models," said Krishnamurthy, who also serves as a research associate for Iowa State University's Center for Multiphase Flow Research and Education. "Another advantage is that we are able to 3D print MRI and CT scan data such as cardiac models."

For this project, the researchers utilized Computer Aided Design (CAD) and Computer-Aided Manufacturing (CAM) techniques, with computational geometry to compute the part boundary and infill for the additive manufacturing of CAD models. Ghadai, Ph.D.



Above: *Pipeline of the researchers' direct 3D printing approach.*

Below: *Print comparison of the MLMS approach with standard STL printing. The MLMS approach has a better surface finish with lower stair casing artifacts.*



student, was responsible for developing the multi-level marching squares (MLMS) algorithm and the code, while Jignasu, undergraduate student, handled the 3D printing and testing of various models and compared their print quality. Krishnamurthy oversaw the entirety of the project and advised his students as necessary.

Adarsh Krishnamurthy

This project builds upon past work done by Krishnamurthy, particularly a 2018 article that he co-authored with Gavin Yong in the journal *Computers & Graphics*, that uses graphics processing units (GPUs) to construct multi-level voxelization of complex CAD geometries.

Krishnamurthy said he thinks their most recent findings can be applied to future additive manufacturing projects, such as when generating an end-to-end system for 3D printing which works solely on voxelized geometries. The findings from this research may have some applications directly relevant to industries in Iowa, especially with the increased interest in additive manufacturing. They hope to partner with Iowa State University's Center for Industrial Research and Service (CIRAS) to help Iowa industries adopt this new methodology.

Sambit Ghadai

"It can be used for rapid prototyping purposes as one of the main advantages of using our method is better surface finish and the ability to 3D print dense volumetric data, without requiring complicated CAD cleanup," said Krishnamurthy, adding that they hope to work with the Iowa Economic Development Authority to develop an additive manufacturing pipeline for secure cyber manufacturing.

Anushrut Jignasu

Work on this project started during Fall 2019. Funding was provided in part by the National Science Foundation (Grants 1644441 and 1750865). The journal article was published open access through a Iowa State University Open Access Subvention Grant.

MEs take top prizes during campus-wide research poster competition

Mechanical engineering students had an impressive showing during the Research Days 2021 competition, hosted in March by Iowa State University's Office of the Vice President for Research.

Saurabh Aykar, Ph.D. candidate in mechanical engineering (ME), took first place in the People's Choice category in the iPoster competition — which was hosted through the iPoster platform — while Jessica Brown, Ph.D. student in ME, won the Best Commercialization Potential category.

Judges and sponsors for the Best Commercialization Potential award included Alison Doyle, Chief Relationship Officer at the Iowa State University Research Park, and Peter Hong, director of the ISU Startup Factory. The People's Choice award category allowed event attendees to vote for their three favorite iPosters. Both awards were new this year. Aykar will receive a $300 gift card as a prize, while Brown will receive a $100 gift card.

Aykar's research looked at manufacturing bio-compatible hollow polymer-based microvessels using microfluidics to mimic the human microvasculature network in-vitro that can subsequently be used for drug discovery/testing applications.

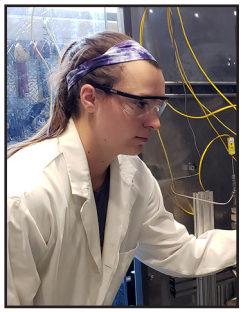
"I am grateful for the recognition I have received for my research work and I would like to specially mention my professor, Dr. **Nicole Hashemi**, for constantly motivating me to achieve success," said Aykar, who is advised by Hashemi, associate professor of ME.

Brown's project focused on thermal oxo-degradation of plastics in the environment. She and her research team found that by adding oxygen to the system, it accelerates the chemical reactions and adds functionality to the fragmented molecules.

"Considering the high quality of research performed across Iowa State's campus, I was honored to receive this award. Commercialization of plastic upcycling has been hampered due to a gap between the costly energy input and the value of products. With support from the Bioeconomy Institute and DARPA, my research aims to bridge this gap and improve the viability of plastic thermochemical conversion," said Brown, who is advised by **Robert C. Brown** (no relation), distinguished professor in ME as well as the Anson Marston Distinguished Professor in Engineering and Gary and Donna Hoover Chair in Mechanical Engineering.

Saurabh Aykar

The format for this year's Research Days event was adapted for COVID-19 protocols. The event was entirely virtual and there were 29 total research posters that were part of this year's gallery. While the traditional in-person format has its benefits, this revised format created opportunities that might not have otherwise been available to both the presenters and the attendees, according to Peter Dorhout, Vice President for Research at Iowa State University.



Jessica Brown

"Viewing times were greatly extended, offering more flexibility, and the content presented as part of the iPoster multimedia platform was richer," Dorhout said in a speech during the competition's award ceremony. "We hope the iPoster gallery has provided you with opportunities to interact with many researchers, and that you'll continue the conversations started this week in the weeks and months to come."

ME grad student recognized at international conference

Emily Johnson, a mechanical engineering graduate student, recently received the Best Presentation Award for Junior Female Researchers at the 14th World Congress on Computational Mechanics and ECCOMAS Congress 2020 virtual conference. Elsevier and the Female Researchers Chapter of the International Association for Computational Mechanics supported this merit-based award to highlight the work of junior female faculty in the field of computational mechanics.

Emily Johnson

Johnson is a Ph.D. candidate in mechanical engineering and the graduate program in Wind Energy Science, Engineering and Policy. Her work focuses on developing computational approaches to analyze complex engineering applications, including wind turbine blades and heart valves. Johnson presented work entitled "Parameterization, Geometric Modeling, and Isogeometric Analysis of Tricuspid Valves."

MEs team up with Iowa Army National Guard to improve building resiliency

When the Iowa Army National Guard was looking for ways to improve the environmental sustainability of their facilities, they called upon the expertise of mechanical engineering researchers at Iowa State University.

Song-Charng Kong

Song-Charng Kong, mechanical engineering (ME) professor at Iowa State, led the effort. Former graduate student Benjamin Robertson, who completed his M.S. in ME in August 2020, assisted Kong. The project was the basis for Robertson's thesis, *Building energy efficiency retrofit prioritization: A case study of the Iowa Army National Guard.*

The researchers analyzed the energy and water usage at Iowa Army National Guard (IAARNG) facilities to determine which buildings would be most suitable for energy retrofits in an effort to lessen energy and water usage rates. The IAARNG maintains more than 200 facilities across the state, ranging from classrooms and offices to repair shops and manufacturing facilities to warehouses and living quarters.

"We analyzed the data, ranked the buildings and facilities according to their energy and water consumptions, and identified strategies to increase the resilience of their facilities in case of disasters," Kong said.

Kong connected with the IAARNG through Iowa State University's Electric Power Research Center, where he is a research associate. Kong got involved with the project because of his expertise in building energy usage. Work on this project started in August 2018 and the researchers wrapped up their report in August 2020.

This project built upon past work on which Kong has collaborated with IAARNG examining combined heat and power generation for the Guard's main facility in Fort Dodge.

"In that project, we studied the feasibility of using diesel engines or micro turbines to provide heat and power to the Fort Dodge facility," said Kong. "Both projects are within the realm of energy security."

This emphasis on energy security is part of a broader effort by the U.S. Army, and the entire Department of Defense, to maintain resilient facilities able to adapt to changing conditions, both within the United States and abroad. The Department of Defense is the largest energy consumer within the U.S. federal government.

"Maintaining our tactical and strategic edge heavily depends upon the wise use of our resources — energy, water, and land — to preserve future choices through superior knowledge, technologies, and execution," Gen. Daniel B. Allyn, U.S. Army Vice Chief of Staff, and Brad R. Carson, Under Secretary of the Army, wrote in a 2015 report.

Kong said that the analytical methodology from his most recent project can be applied to other government or industry complexes that are looking for strategies to increase resiliency. In addition to providing a valuable service to the IAARNG, Kong said this project was also beneficial to Robertson, his former graduate student, who was hired by Helm Group after completing his graduate studies at Iowa State.

"Benjamin learned a lot by tackling the real-world problems. This experience helped him to prepare for his career in the industry," Kong said.

Hashemi elected a Fellow of the American Society of Mechanical Engineers

Mechanical engineering associate professor **Nicole Hashemi** has been named a Fellow by the American Society of Mechanical Engineers (ASME).

The status of Fellow is bestowed upon an ASME Member with 10 or more years of active practice and at least 10 years of active corporate membership in the organization. Of the more than 100,000 ASME Members, about 3,000 have attained the grade of Fellow

Nicole Hashemi

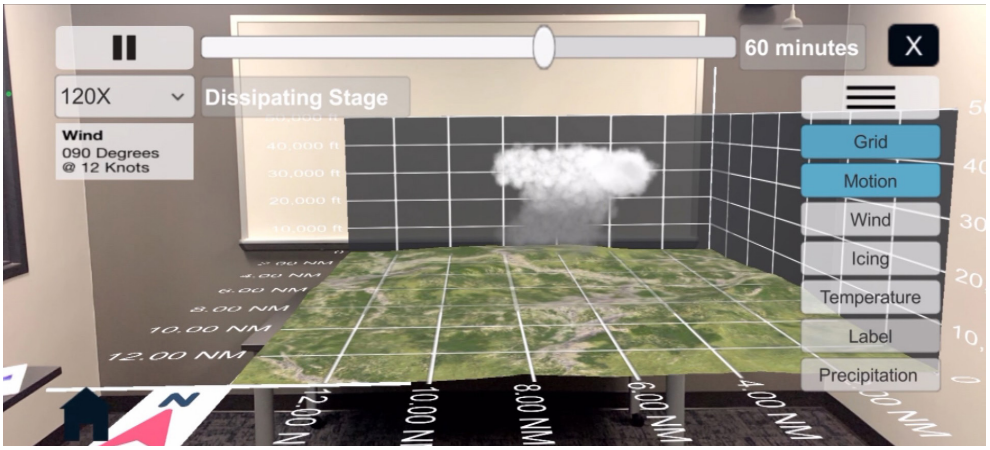
Hashemi is using her expertise with the microfluidic manufacture of 3D scaffolds to study traumatic brain injury (TBI) and describe the damage to brain cells caused by the cavitation. These microstructures could be used to investigate other injury and disease models

Hashemi is the 11th current ME faculty member to hold the grade of Fellow from ASME.

Research project simulates weather conditions for pilots in training

Navigating realistic weather conditions during the pilot training process could became easier because of an Iowa State University research project involving augmented reality (AR).

Michael Dorneich, associate professor of industrial and manufacturing systems engineering, and **Eliot Winer**, professor of mechanical engineering and director of the Virtual Reality Applications Center (VRAC), are leading the Iowa State University effort for the Augmented Weather Interfaces Project (AWIP), which is part of the Federal Aviation Administration's Partnership to Enhance General Aviation Safety, Accessibility, and Sustainability (PEGASAS).



A screenshot from the Augmented Weather Interfaces Project (AWIP) application.

"The goal of our work is to apply augmented reality, or AR, capabilities to enhance general aviation weather training," said Philippe Meister, a Ph.D. candidate with co-majors in rhetoric and professional communication as well as the human computer interaction (HCI) graduate program.

The Iowa State University (ISU) team collaborates with researchers at Western Michigan University (WMU) for the project, which is part of a bigger AWIP effort led by Barrett Caldwell, a professor of industrial engineering at Purdue University. The team designs and develops new 3D AR weather models, learning modules, and assessment tools as well as materials that help the flight training community learn to use the new AR capabilities. These capabilities are being integrated into WeatherXplore, a weather training application developed by WMU to connect digital content with aviation educational material.

Work on this two-year project began in October 2019 and thus far, the team has developed a three-dimensional model of a single-cell thunderstorm and delivered it using augmented reality technologies and smartphones. In the next phase of the work, they will develop 3D AR thunderstorm learning materials and will assess the benefits of using the 3D AR materials compared to traditional print materials.

Winer, and his graduate students Jack Miller and Kexin Wang, built 3D weather models and delivered them with augmented reality technologies. Dorneich and Meister then applied training techniques to design effective learning activities with these models. The goal is to integrate these new activities into existing training curriculums. Additionally, Dorneich and Meister will apply human factors methods to evaluate the effectiveness of the AR-enhanced curriculum compared to a traditional print curriculum.

This project builds upon previous research Winer and Dorneich have conducted through VRAC. Previously, Winer used AR to provide augmented assembly instructions of airframe elements for shop floor technicians, showing that assembly was dramatically faster and had fewer errors. Dorneich has worked extensively with the FAA to develop and evaluate aviation-related technologies.

"In our current project, we are applying AR to classroom training of pilots, and exploring how best to integrate AR into traditional printed learning materials to enhance ground training of pilots," Dorneich said.

Lori Brown and Geoff Whitehurst, both associate professors in the College of Aviation at WMU, contributed their expertise in aviation weather and utilizing digital content in the classroom. Meister, who majored in writing as an undergraduate at the University of Wisconsin-La Crosse and also holds a M.A. in rhetoric and professional communication from Iowa State University, brought his background in technical communication.

"I use communication strategies to make the learning experiences logical, credible and impactful. I use HCI methods to design the AR learning experiences, improve the experiences through iterative testing and measure learning outcomes," said Meister, adding that he also applied material that he learned in Dorneich's Design and Evaluation for Human Computer Interaction course.

"At the end, I will evaluate the AR-enhanced learning experience compared to the traditional experience to assess the benefits of AR-enhanced learning for students in GA weather training," said Meister. "I am really interested in how people are using new media technologies in professional settings to communicate technical information."

ME's Zobeiri named Brown Graduate Fellow

Mechanical engineering graduate student Hamidreza Zobeiri is among 14 students across the entire university, and just three from the College of Engineering, to be named a Brown Graduate Fellow for 2021-22.

"I was really happy and excited about it, because I knew that this award is very competitive," said Zobeiri. "For me, winning this award means that my research has been recognized, and it further motivates me in my graduate studies to work harder."

Hamidreza Zobeiri

As part of the award, Zobeiri will receive $10,000 in institutional funding, "which can be used to enhance existing fellowships, partially fund a fellowship, or assist with recruitment of new graduate students."

Zobeiri works in the Micro/Nanoscale Thermal Science Laboratory and is advised by **Xinwei Wang**, professor of mechanical engineering (ME). Their research largely focuses on thermal transport at the micro and nanoscales, analyzing materials such as thin films and fibers. Zobeiri's recent research has examined the thermal characterization of 2D materials using various methods, such as Raman spectroscopy.

Zobeiri was nominated for the Brown Graduate Fellowship by **Pranav Shrotriya**, professor and Director of Graduate Education for the ME department.

"Hamidreza is currently…doing research on the science of energy transport in 2D atomic layer materials, including novel probing characterization development, advanced theoretical analysis, and physics interpretation. His research contributions are expected to have a very long and profound impact in micro/nanoscale thermal science," Shrotriya wrote in a letter nominating Zobeiri for this honor.

Zobeiri is originally from Iran and came to Iowa State University after completing his B.S. in ME from the University of Tehran. He said he was attracted to Iowa State because of its strong specialized faculty, particularly Wang, whose research aligns most closely with his professional aspirations. During his time in the ME department at Iowa State, Zobeiri said he appreciates support he's received from faculty and staff as well as fellow students.

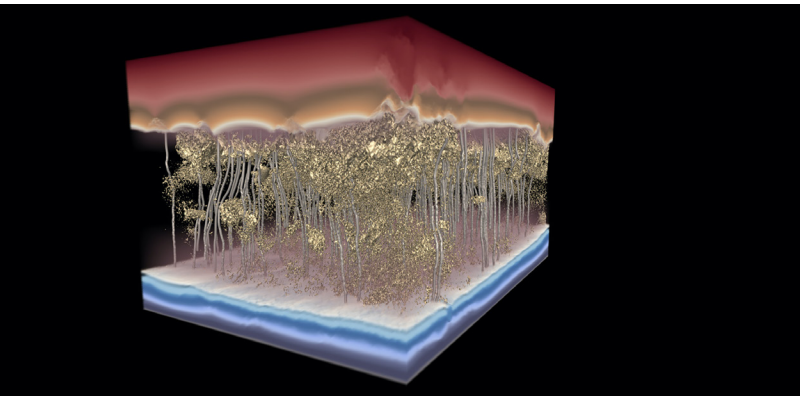
"I want to thank all the people that I have worked with during the last three or four years, especially Professors Wang and Shrotriya, for their support," he said.

When he's not busy in the lab, Zobeiri enjoys reading and cooking. He said has been trying out new dishes from different cultures. He also enjoys playing soccer and walking through the numerous parks in Ames, particularly during the spring and summer. As an amateur photographer, he often takes his camera out during his walks. He advises any future students coming from Iran or other warm regions to "be prepared for really cold winters" but added that he's found the people of Ames to be friendly which helped him to adapt to life in Iowa shortly after arriving.

Zobeiri, who is currently in the fourth year of his Ph.D. program, plans to complete his studies in either Spring or Summer 2022. He said he is still considering his career options for after graduation but has a strong interest in continuing to conduct research and working on new problems in his field.

A shot of a blooming tree in Ames that Zobeiri took during the spring of 2020.

Researchers measure, model desalination membranes to maximize flow, clean more water



This 3D model of a polymer desalination membrane shows water -- the silver channels, moving from top to bottom -- avoiding dense spots in the membrane and slowing flow. Larger image. Image by the Ganapathysubramanian research group/Iowa State University and Gregory Foss/Texas Advanced Computing Center.

Nature has figured out how to make great membranes.

Biological membranes let the right stuff into cells while keeping the wrong stuff out. And, as researchers noted in a paper just published by the journal Science, they are remarkable and ideal for their job.

But they're not necessarily ideal for high-volume, industrial jobs such as pushing saltwater through a membrane to remove salt and make fresh water for drinking, irrigating crops, watering livestock or creating energy.

Can we learn from those high-performing biological membranes? Can we apply nature's homogenous design strategies to manufactured, polymer membranes? Can we quantify what makes some of those industrial membranes perform better than others?

Researchers from Iowa State University, Penn State University, the University of Texas at Austin, DuPont Water Solutions and Dow Chemical Co. – led by Enrique Gomez of Penn State and Manish Kumar of Texas – have used transmission electron microscopy and 3D computational modeling to look for answers.

Iowa State's **Baskar Ganapathysubramanian**, the Joseph C. and Elizabeth A. Anderlik Professor in Engineering from the department of mechanical engineering, and Biswajit Khara, a doctoral student in mechanical engineering, contributed their expertise in applied mathematics, high-performance computing and 3D modeling to the project.

The researchers found that creating a uniform membrane density down to the nanoscale of billionths of a meter is crucial for maximizing the performance of reverse-osmosis, water-filtration membranes. Their discovery was the cover paper of the Jan. 1 print edition of the journal *Science*.

Baskar Ganapathysubramanian

Working with Penn State's transmission electron microscope measurements of four different polymer membranes used for water desalination, the Iowa State engineers predicted water flow through 3D models of the membranes, allowing detailed comparative analysis of why some membranes performed better than others.

"The simulations were able to tease out that membranes that are more uniform – that have no 'hot spots' – have uniform flow and better performance," Ganapathysubramanian said. "The secret ingredient is less inhomogeneity."

Just take a look at the *Science* cover image the Iowa State researchers created with assistance from the Texas Advanced Computing Center, said Khara: Red above the membrane shows water under higher pressure and with higher concentrations of salt; the gold, granular, sponge-like structure in the middle shows denser and less-dense areas within the salt-stopping membrane; silver channels show how water flows through; and the blue at the bottom shows water under lower pressure and with lower concentrations of salt.

Biswajit Khara

"You can see huge amounts of variation in the flow characteristics within the 3D membranes," Khara said.

Most telling are the silver lines showing water moving around dense spots in the membrane.

"We're showing how water concentration changes across the membrane." Ganapathysubramanian said of the models which required high-performance computing to solve. "This is beautiful. It has not been done before because such detailed 3D measurements were unavailable, and also because such simulations are non-trivial to perform."

Khara added, "The simulations themselves posed computational challenges, as the diffusivity within an inhomogeneous membrane can differ by six orders of magnitude"

So, the paper concludes, the key to better desalination membranes is figuring out how to measure and control at very small scales the densities of manufactured membranes. Manufacturing engineers and materials scientists need to make the density uniform throughout the membrane, thus promoting water flow without sacrificing salt removal.

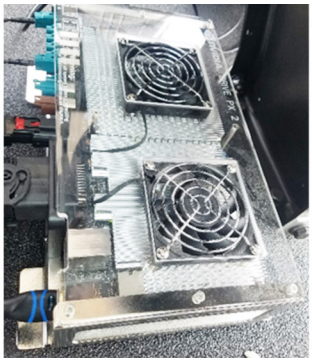
It's one more example of the computational work from Ganapathysubramanian's lab helping to solve a very fundamental yet practical problem.

"These simulations provided a lot of information for figuring out the key to making desalination membranes much more effective," said Ganapathysubramanian, whose work on the project was partly supported by two grants from the National Science Foundation.

Contributed by Mike Krapfl/ISU News Service

New cyber-physical systems minor leverages industry ties to enhance student futures

A first-of-its-kind curriculum in Iowa will soon be available to students in Iowa State University's College of Engineering – and will help prepare them for a cutting-edge area of technology that's part of what has been deemed "the fourth industrial revolution."




Many types of student projects will benefit from the cooperative spirit of the cyber-physical systems minor.

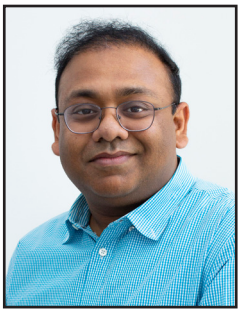
A new undergraduate minor in cyber-physical systems (CPS) will debut in the Fall 2021 semester. It will be open to all Iowa State engineering majors, and will combine teaching efforts from three different College of Engineering departments: mechanical engineering, electrical and computer engineering, and aerospace engineering – with mechanical engineering serving as the home and administrative department for the program.

It will provide students with a foundation in the techniques of CPS – engineered systems that are built from, and depend upon, the seamless integration of computation and physical components. Many safety-, time- and life-critical systems now rely on CPS to become more efficient, robust, resilient, flexible, scalable, and secure. Examples of where CPS technology is utilized include smart power grids, medical monitoring, automated aviation systems, robotics, industrial control systems and more.

As the CPS applications become more common, a critical need to train the next generation of a workforce which can design, produce and maintain these systems has been identified. The program has been developed in cooperation with College of Engineering industrial stakeholders – companies that maintain important relationships with the university and employ College of Engineering graduates. They have cited the need for educated CPS engineering professionals as a key enabler to the successful creation of these systems, not only within their companies but throughout all of industry – and have applauded the plan for its potential economic impact on Iowa and the nation through training future engineers who will aid in the advancement of this technology.

The minor will focus on sensing, advanced information processing (data analytics and machine learning), and controls aspects of cyber-physical systems. Specific CPS application sectors – energy/power systems, manufacturing, biomedical devices, autonomous systems, transportation, and agriculture – will be highlighted.

Students with a minor in CPS will complete 15 credits, nine of which will come from three required 3-credit courses, with each contributing department offering one course. Elective courses will provide six additional credits toward the minor.



Soumik Sarkar

Soumik Sarkar, associate professor, mechanical engineering, and professor-in-charge of the CPS minor, praised the inter-departmental teamwork in setting up the minor, as it reflects the real-world aspect of the discipline. "Cyber-physical systems is an inherently interdisciplinary area of study that brings together concepts of mechanical engineering, electrical engineering, computer and software engineering with applications relevant to all other engineering departments such as aerospace engineering and civil engineering. This promotes collaboration that is indispensable to an effort like this."

"The CPS minor is another example of how the College of Engineering emphasizes science with practice in our curricular offerings – it meets a growing need in our industry and will position our students well for the workforce of the future," commented **Sriram Sundararajan**, Associate Dean for Academic Affairs.

Arum Somani, Associate Dean for Research, cited responsiveness to an opportunity to extend the college's strong cooperation with industry. "This program is an excellent example of how Iowa State is responding to an emerging need. Multiple industry brought the needs to our attention. Our departments quickly came together to develop a solid program, based on ongoing research in the college, and which was vetted by our industrial partners. The final program is designed to serve common multiple industry needs and will create a CPS-aware workforce that will make our graduates more marketable."

Contributed by John Burnett-Larkins/ Engineering College Relations

From delivering groceries to climbing the career ladder with Deere

Growing up, John Lawson thought he would eventually take over the family grocery store. However, his father inspired him to pursue a different career path.

In his youth, Lawson spent many hours working for his family's downtown Moline, Illinois, grocery store, and fondly remembers delivering groceries to customers' homes. He figured he would eventually become the fourth generation from his family to run the business, but he said after chain grocery stores began pushing out the smaller, family-run operations in the 1950s his father encouraged him to rethink his career plans.

Some acquaintances Lawson knew through church suggested he look at cooperative (co-op) opportunities available with John Deere. Lawson was familiar with Deere, which is headquartered in Moline, because of his maternal grandfather, John Rosenberg, who worked for 53 years in a machine shop at the Moline plant.

Lawson learned to be eligible for the Deere co-op program he would need to study either mechanical engineering or agricultural engineering at either Iowa State University or the University of Illinois at Urbana-Champaign. He decided to pursue mechanical engineering at Iowa State.

The College Years

To participate in the Deere co-op program, Lawson needed to prove himself by maintaining good grades during the first couple of quarters his freshman year. (Iowa State was on a quarter system until 1981.) Even though Lawson admits he was not a "super student," his grades passed the threshold. He said he was forever grateful for the co-op's schedule that alternated working full-time for a quarter to save up money with attending class full time for a quarter. During this era, he remembers paying around $200 per quarter for tuition as a non-resident.

Even though he was on and off campus a lot because of his co-op, Lawson still had the opportunity to get the full college experience. He pledged Sigma Alpha Epsilon, lived in the fraternity's elegant brick and stone house on Lynn Street and even served a term as the fraternity's president. He also had the opportunity to serve as president of the Pep Council and was a member of the student chapter of the American Society of Mechanical Engineers. However, he admits he did miss out on some things.

John Lawson

"Because I was in and out of school every quarter I wasn't able to actively participate in planning events like homecoming and VEISHEA, but I am grateful I was able to be as engaged with my fraternity as I was," he said.

In class Lawson remembers longtime ME chair and professor **Henry Black** made an effort to engage with all students, even freshmen, and that left a lasting impact on him. Lawson also remembers professors such as **Delmar Van Meter**, **Bill Bathie** and **Robert Fellinger**, whom he described as "a tough teacher but respected."

"I learned early on that you wanted to sit in the front row of the classroom," said Lawson. "The professors were more likely to call on students in the back row, especially if they weren't paying attention."

Lawson eventually developed his own unique way for approaching final exams.

"For finals, you don't stay up all night. You get a good night's sleep before the exam," he said. "I also wore a collared shirt and tie to the exam just because it made me feel more upbeat and positive."

Lawson's most treasured memory from his time at Iowa State, came when he met Sue, his now-wife of 58 years. Lawson's fraternity brother Dale Johnson, who also happened to be a graduate student and instructor in ME, and his then-fiancé Jan Hansen set up John and Sue for a blind date. (Jan and Sue were both in Kappa Alpha Theta sorority.) The soon-to-be couple decided to meet each other for the first time on the steps of Beardshear Hall after class one afternoon just to chat. Two days after that, they went out for their first official date. Half a century later John and Sue would take a photo on the steps of Beardshear to commemorate their 50th anniversary.

Right: *John Lawson, circled in cardinal, poses with other members of the Pep Council. Lawson's now-wife Sue is circled in gold.*

A Career with Deere

John and Sue, an English major, both graduated in the spring of 1962, and the couple wed four weeks after graduation. John started working for Deere immediately out of college, and after three years on the job, the company asked him if he would move to Germany to work at Deere offices in Heidelberg and Mannheim. Sue, who lived near Frankfurt after World War II, was ecstatic for the opportunity, so the family (which now included one-year old Robert) packed their bags and moved halfway across the world. The basic German skills Sue picked up during her time there as a youth proved to be invaluable for them when doing everything from navigating street signs to reading menus. John's work in Germany involved reviewing expenditures and providing technical engineering assistance.

"It was a wonderful experience and a great opportunity for me to deepen my understanding of the company. I got to do and see things that just wouldn't have been possible if I was working back in Moline," he said, adding that during his time off the family had the opportunity to travel all over Europe.

Once the family returned stateside, Lawson transitioned into more of a supervisory role with Deere and had stints at facilities in the Quad Cities, Des Moines, Horicon (Wisconsin) and Dubuque. He appreciated these supervisory roles because it allowed him to work more directly with other people, which he felt was his strength.

While Lawson had a successful career, it was not without its trying times. He and the rest of the company were challenged economically and in other ways during the farming crisis of the 1980s when demand for tractors, combines and other equipment dropped.

"Without the help of a lot of good people, it would have been very difficult to get through that," he said.

Throughout the 1980s and 90s Lawson continued to climb the career ladder at Deere rising from vice president of Manufacturing, Agricultural Equipment Division to president of the Construction Equipment Division to president of the Lawn and Grounds Care Division and finally as senior vice president for technology and engineering. During his final ten years with the company, he was one of ten senior officers and reported directly to the CEO. Lawson retired in 2002 after 44 years, including four years of co-op experience in college. He jokes that he fell a little short of his grandfather's 53-year tenure with the company.

Reflecting On Everything

The Lawsons have done much to give back to Iowa State University since their days as students. John has served as a liaison between the university and Deere to help get students internships, co-ops and eventually careers with the company, as well as to support and coordinate research projects between Iowa State and Deere. He was a member of the ISU Foundation Governors and formerly chaired the ISU Foundation Board of Directors.

The Lawsons have supported many ISU efforts over the years, but in particular, they have established scholarships to help students fund their education. While the ME department is near to John's heart, and the English department to Sue's, they felt it important to support students in all majors, particularly the students with the greatest need. The Lawsons have supported nearly 350 scholarships for roughly 180 individual students.

"We like to support the student who doesn't necessarily have credentials like being class president or having a four-point-zero grade average," said Lawson. "We feel extremely blessed to be able to do this and it almost brings tears to your eyes to read the notes from the students we've supported over the years. Many have been first generation college students and many have said they would have to work long hours or make other major sacrifices to get through college without the extra support."

Even with all that he has going on, John manages to find time for hobbies and other things that make him happy. In addition to his philanthropic work, Lawson enjoys golfing and reading. He also tries to bike four to five miles each day. Family is also important and he enjoys staying connected with his children and grandchildren, one of whom is currently a freshman business student at Iowa State.

"Nothing gives me more satisfaction than when they call, text or Facetime me just to check in," he said.

Even though it has now been nearly sixty years since he graduated, Lawson thinks about the impact Iowa State University had on his life and career nearly every day. He is quick to recognize that he had a lot of help from many people to get to where he did, which is why it has been so important for him and Sue to give back whenever they can.

"I can't say enough about the good fortune I've had between my time at Iowa State and my time with Deere," said Lawson. "My biggest advice, which I always tell my grandchildren, is to maintain a positive attitude and practice common sense in your decision making."

Right: *John and Sue pose on the steps of Beardshear Hall to commemorate their 50th anniversary.*

Khloe, a two-year-old Cardigan Welsh Corgi owned by ME communications specialist Nick Fetty, poses by the campanile.