MTUengineering

ME-EM

MECHANICAL ENGINEERING - ENGINEERING MECHANICS

2022-23 ANNUAL REPORT

MACHINE LEARNING

A KALEIDOSCOPE OF RESEARCH APPLICATIONS

Michigan Technological University

1885

MESSAGE FROM THE CHAIR

As the chair of the ME-EM department at Michigan Tech, it is my honor to thank you for reading our annual report. Thank you for supporting the department. We missed sending out an annual report last year due to the significant transition in leadership. Dr. William (Bill) Predebon, who had diligently served as chair for 25 years, passed the mantle to me.

Now, with a heavy heart, I must share the news of Bill's passing on July 21, 2023. This has undeniably been a difficult time for our department. Even though Bill retired on June 30, 2022, he continued to visit us and offer his invaluable guidance and wisdom as a mentor and friend. To say that Bill was the most impactful chair to ever serve at MTU is an understatement. He beautifully transformed the department under his tenure. For that, and for his tremendous kindness and support, we are forever grateful. He was a great friend, man, colleague, and leader, and will be missed ad infinitum.

The department continues to energetically pursue a wide range of innovative research. Recently, Dr. Hassan Masoud was honored with a prestigious National Science Foundation CAREER Award for his work on "Collective Hydrodynamics of Robotic Swimmers and Surfers at High Reynolds Numbers." In a recent collaboration with Sandia National Laboratories, we celebrated the launch of our US Department of Energy Solar Energy Regional Test Center (RTC) under the dedicated leadership of Dr. Ana Dyreson. Leading a highly promising effort in plastics recycling, Dr. Ezra Bar-Ziv and Dr. Fei Long are making great strides on a continuous process for solvent-targeted recovery and precipitation (STRAP) for plastic waste. They are building a pilot plant to run the process on a larger scale. We see expansion of research in projects related to the lunar surface. We also see the growing use of AI and machine learning applications in research.

Our students enjoy success in a variety of competitions. Recently, the Planetary Surface Technology Development Lab/ HuskyWorks advanced to the next round of NASA's Watts on the Moon Challenge. Our students show creativity and energy when competing in SAE Motorsports competitions, and in various research paper and poster competitions. Their curiosity and achievements inspire our incoming student classes, which grow in size year after year.

Thank you for your support—and for recognizing the value and achievements of our faculty, staff, and students. We all appreciate it and strive to continue pushing the envelope in many ways.

Thank you,

Jason R. Blough, PhD
Department Chair and Distinguished Professor

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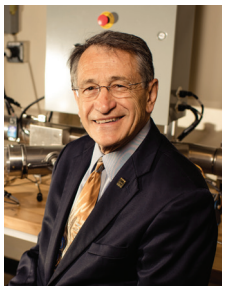

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On the Cover:
Master's student Luke Schloemp tests a two-body point absorber wave energy converter (WEC) in MTU Wave, ME-EM's on-site wave tank. Modeling and control research uncovers how WEC design affects its dynamic response. We use machine learning to estimate wave forces before they impact the buoy, enhancing its ability to extract energy.

DARRELL'S DYNO:
ADAPTING TO CHANGING MOBILITY ENGINEERING

Engineers love to design, build, and iterate to adapt a project to changing boundary conditions. But when conditions affecting whole engineering fields change dramatically, it spurs a paradigm shift in engineering research and education.

Darrell Robinette, an associate professor in the ME-EM department, has watched just such a shift occur within the area of mobility systems.

"Engineers are increasing the degree of electrification within the propulsion system, increasing the number of advanced driver assist systems, and increasing autonomous driving capabilities and data connectivity," he says.

These advances demand more from engineering graduates.

"The sophisticated systems in engineered mobility products require new engineers to possess advanced skills and approaches. They need to be able to contribute technologies, and advance the state of art."

Robinette joined the faculty at Michigan Tech in 2016 after nearly a decade of product development work at General Motors. He had a vision for a flexible and adaptable research and educational space. At Tech, he made it a reality.

Robinette designed and built a 900-square-foot dynamometer (dyno) test cell located off campus at Michigan Tech's Advanced Power Systems Research Center, also called APS LABS. To fund it, he used his academic startup package, along with added research funding from Ford Motor Company and General Motors and support from BorgWarner, John Deere, and Raven Engineering.

"I wanted to conduct research and educational projects on the dyno. The vehicles would range from conventional to fully electric. And I wanted to base it on my experiences at GM."

Robinette named his dyno cell ADaPT, short for Advanced Drivetrain and Powertrain Technologies.

"The cell could accommodate engines, transmissions, full powertrains, and even vehicles—it really could adapt to a variety of research needs and evolving technologies."

Then things changed.

Coming out of the pandemic, Robinette observed a dramatic shift in mobility engineering: a shift to full electrification, plus heavy software integration for full autonomous driving and connectivity.

Robinette's own research, as well as the engineering education of students at Michigan Tech, also had to make the shift.

"With a drying up of the well for conventional or even electrified powertrain research funding, our use of the ADaPT cell did just that. It adapted."

The SAE AutoDrive Challenge II, the second iteration of the GM- and SAE-sponsored collegiate competition, asks students to engineer and field an SAE Level 4 (L4) autonomous vehicle. Robinette serves as co-advisor of the MTU team along with Jeremy Bos, an associate professor of electrical and computer engineering.

Entering the competition, the team faced some significant challenges. "We had no suitable on-campus vehicle build bays or sufficient closed test tracks, and our window is short due to the deep snow on the ground in Houghton from November to May."

It was clear to Robinette what the team needed: his dyno cell. To make it happen, he created slight modifications to ADaPT,

including the addition of new coupling hardware from Raven Engineering. This enabled the team's Chevy Bolt EUV to be tested on dyno for both longitudinal and lateral control.

"We now have a unique capability only available in a handful of facilities, including Oak Ridge National Laboratory."

The capability is in-the-loop testing, a stopgap method meant to make up the difference between computer-simulated testing and full road testing. Hardware, software, and even full vehicles can be tested "in the loop," says Robinette.

"OEMs have been migrating over to this approach for the last 30 years, moving all hardware, software, and vehicles in the loop to dynos. Moving off the test tracks and roads not only reduces cost and development times—it improves their ability to test the edge case."

Edge cases happen when conditions or situations at the edge of operating constraints cause problems. Robinette's dyno can accomplish edge case tests at Michigan Tech.

Robinette renamed his new iteration of the dyno: Automated Driving and Propulsion Technology cell—ADPT for short.

But to Michigan Tech's AutoDrive Challenge II students, it's simply "Darrell's Dyno." Using it, they can now test and validate their competition vehicle, software, and hardware in the loop—creating virtual test and infrastructure scenarios in available software. And the work can be done year-round.

Robinette's short-term goal with the dyno was to give students a tool—one that would allow them to succeed in the AutoDrive Challenge II and also position them well for mobility systems careers. His students appreciate it. They nominated Robinette for Advisor of the Year during the 2023 Autodrive Challenge II. He received his award on June 10.

The team did well, too. They took third place in Overall Dynamic Challenges, and second place in the Highway Challenge, Concept Design Report & SRS, and Concept Design Event.

As for Robinette's longer-term goal? " I hope I've succeeded in positioning and equipping Michigan Tech with a research facility asset that can compete for funding in the ever-changing mobility systems space."

MICHIGANDER EV SCHOLARS

Michigan Tech is partnering with the Michigan Economic Development Corporation (MEDC) on a pilot program to promote careers in and recruit talent for Michigan's growing electric vehicle (EV) and transportation mobility sector.

Through a series of seminars, networking events, company tours, and more, the Michigander EV Scholars program directly connects Michigan Tech students with representatives from select Michigan companies in the EV and mobility tech industry. Students will build professional connections through one-on-one networking that may lead to internships and careers.

Successful EV Scholars will qualify for $10,000 in scholarship funds when they accept a qualifying job in Michigan's EV industry. Additionally, a minimum $5,000 scholarship (up to $10,000) is available for those accepting qualifying internships in Michigan's EV and mobility tech industry.

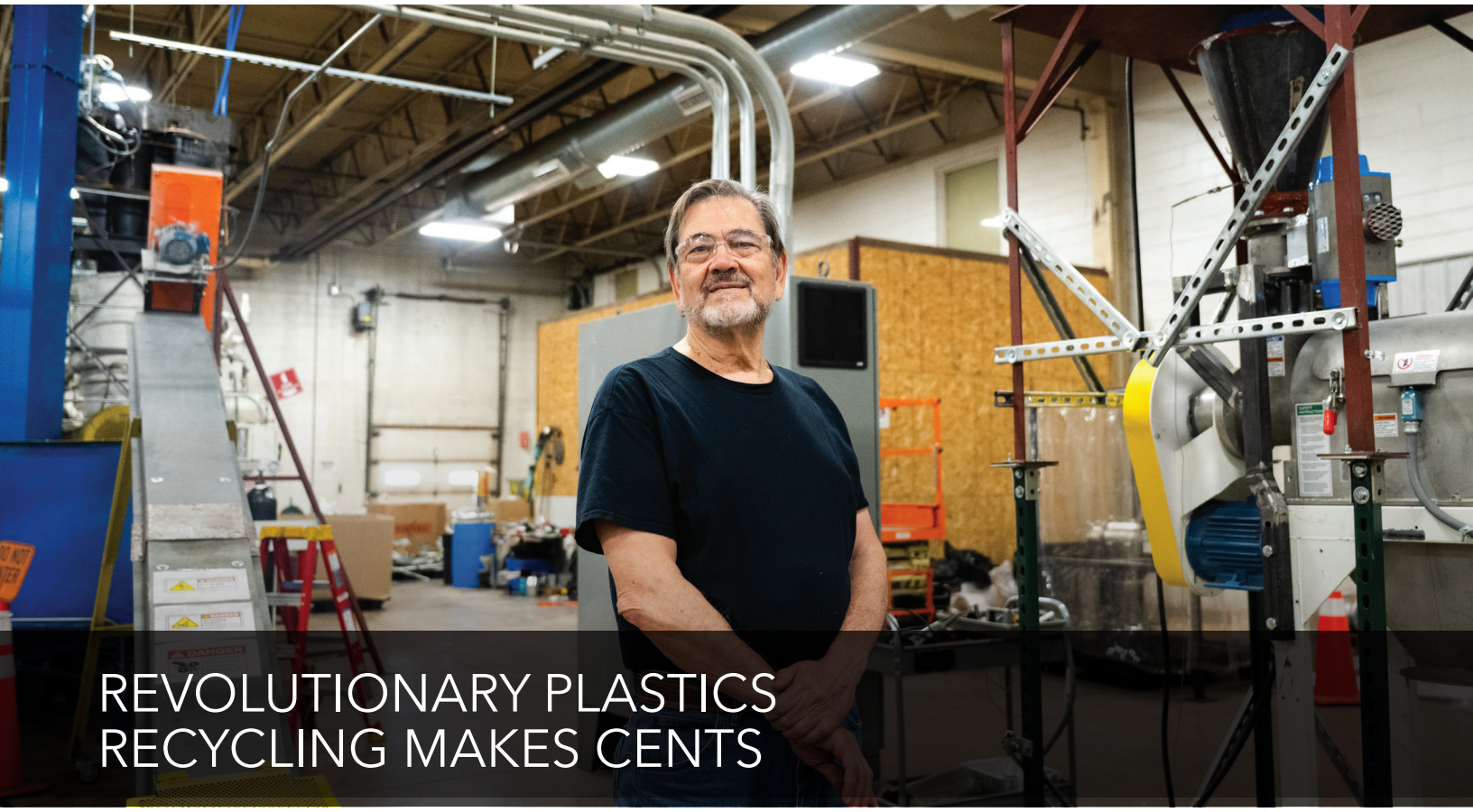
EV Scholars is an initiative of the Talent Action Team, a public/private consortium convened by the MEDC. Other participating universities include the University of Michigan and Michigan State University.

PReP-ING FOR INDUSTRY

In August 2023, Michigan Tech welcomed the first cohort of students to enroll in the Propulsion Readiness Engineering Program (PReP). Developed through an educational partnership between MTU and Stellantis—a leading global automaker and provider of innovative mobility solutions—PReP focuses on training, innovation studies, and applied research in the area of propulsion technology.

The program supplements the last two years of a student's engineering degree and includes weekly lectures from Stellantis propulsion experts. Students earn valuable hands-on experience, learning what it takes to develop a propulsion system from first design concept to vehicle production, and gaining experience with industry tools, methodologies, and testing procedures.

The PReP program also offers opportunities for paid internships and part-time jobs with Stellantis, as well as Stellantis laboratory tours and a unique learning environment that will put them years ahead of their peers and springboard their engineering careers.



REVOLUTIONARY PLASTICS RECYCLING MAKES CENTS

From shoes to pen caps to meat wrappers—90 percent of plastics end up in the trash. Researcher Ezra Bar-Ziv and his team of students have joined a multi-university regional effort to do something about it. They're hard at work scaling up a process development unit that will prove the commercial viability of STRAP: solvent targeted recovery and precipitation.

STRAP targets plastics that cannot be recycled because they're contaminated—with other plastics, dyes or inks, fillers, and other materials. Developed at the University of Wisconsin-Madison by George Huber, Richard L. Antoine Professor in the Department of Chemical and Biological Engineering, STRAP can restore contaminated plastics, including food-grade materials, to their original state for reuse.

Some restored plastics, especially multilayer films, are expensive to produce and will be valuable once recovered. "There is a lot of value in plastic waste. Money is thrown away in the form of plastic each day," Bar-Ziv said.

A mechanical engineering professor with a PhD in Chemical Physics, Bar-Ziv joined forces with Huber after recognizing common interests in their published research. Now, they network globally with others focused on plastic recycling—and this past year, they raised $8 million for STRAP research. Bar-Ziv has received over $4 million in federal, state, and private funding, including $549,954 from the National Science Foundation; $320,658 from the Michigan Department of Environment, Great Lakes, and Energy; and $2.4 million from the US Department of Energy.

STRAP's test process development unit (PDU) was designed and built at Michigan Tech. It produces 55 pounds per hour of recycled resins from flexible and rigid plastics found in municipal waste. A much larger PDU, about two stories tall, is under construction. "We're going from a lab scale, all the way to a ton per hour," said Bar-Ziv. When the PDU is functional and approved, it will anchor the first commercial plastic recycling system in Wisconsin's Green Bay area, operated by Convergen Energy, with plastics coming from local municipal solid waste.

"That's what we're trying to do at Michigan Tech, and we are doing it in strong collaboration with the Madison crew," said Bar-Ziv, who's aware of only three entities in the world able to recycle plastic at plant scale.

The effort is all-consuming, but the long hours bring Bar-Ziv great joy. "I can't wait to get to work each day," he said. Decades of teaching and research culminate in this project—and others aimed at recycling municipal waste to develop clean, renewable energy.

CATCHING UP WITH PAUL VAN SUSANTE

Assistant Professor Paul van Susante says his goal has always been to help humanity establish a permanent presence on the moon, and to improve life on Earth while doing so. To that end, van Susante established Michigan Tech's Planetary Surface Technology Development Lab (PSTDL, also known as HuskyWorks) in August 2019 to prototype, build, test, and increase the technology readiness level of tech being developed for lunar and Mars missions.

"An unavoidable obstacle of space travel is what NASA calls the 'Space Gear Ratio,'" says van Susante, "where in order to send one package into space, you need nearly 450 times that package's mass in expensive rocket fuel. In order to establish a long-term presence on other planets and moons, we need to be able to effectively acquire the resources around us, known as in-situ-resource utilization, or ISRU."

NASA's Artemis program aims to send astronauts back to the moon by 2025 and establish a permanent human presence. Building the necessary infrastructure to complete this task potentially requires an abundance of resources because of the high cost of launching supplies from Earth.

"NASA has several inter-university competitions that align with their goals for their up-and-coming Artemis missions," adds van Susante.

The PSTDL and Multiplanetary INnovation Enterprise (MINE) have numerous Artemis irons in the fire—plus other research projects, too. In the world-class HuskyWorks lab (and in the field), van Susante and his team work on a wide variety of projects:

NASA Lunar Surface Technology Research (LuSTR)—a "Percussive Hot Cone Penetrometer and Ground Penetrating Radar for Geotechnical and Volatiles Mapping."

NASA Breakthrough Innovative and Game Changing (BIG) Idea Challenge 2020—a "Tethered permanently shaded Region EXplorer (T-REX)" delivers power and communication into a PSR (a permanently shadowed region of the moon).

NASA Break the Ice—the latest centennial challenge from NASA, to develop technologies aiding in a sustained presence on the Moon.

NASA Watts on the Moon Centennial Challenge—providing power to a water extraction plant PSR located three kilometers from the power plant. Michigan Tech is one of seven teams that advanced to Phase 2, Level 2 of the challenge.

NASA ESI Early Stage Innovation—obtaining water from rock gypsum on Mars.

NASA NextSTEP BAA ISRU, track 3—"RedWater: Extraction of Water from Mars' Ice Deposits" (subcontract from principal investigator Honeybee Robotics).

NASA GCD MRE—providing a regolith feeder and transportation system for the molten regolith electrolysis (MRE) reactor.

HOPLITE—a modular robotic system that enables the field testing of in-situ-resource utilization (ISRU) technologies.

Prior to joining Michigan Tech, van Susante earned his PhD and taught at the Colorado School of Mines, and also served as a NASA Faculty Fellow. He has been involved in research projects collaborating with Lockheed Martin, Northrop Grumman, SpaceX, TransAstra, DARPA, NASA Kennedy Space Center, NASA's Jet Propulsion Laboratory (JPL), Bechtel, Caterpillar, and many others.

RADHESHYAM TEWARI RECOGNIZED FOR CURRICULUM DEVELOPMENT AND ASSESSMENT EXCELLENCE

Radheshyam Tewari, a teaching professor in the ME-EM department, is an extremely versatile instructor who excels in teaching many courses of different types, sizes, and levels. Recently, Tewari won the Michigan Tech Center for Teaching and Learning 2023 Curriculum Development and Assessment Award.

"Radheshyam has always done a great job in the classroom," said Jason Blough, chair of ME-EM. "Students are drawn in due to his reputation, passion, and commitment. He is completely committed to the students and does a great job each and every day."

The passion and motivation Tewari brings to his teaching is very evident in the classroom, as a message from one of his former students testifies: "I want to let you know of the huge impact you have had on my life. You are a great teacher. I've been in the manufacturing industry for the last two and a half years, and everywhere I go, I share some of the knowledge I learned from you. Thank you for being an amazing coach."

Tewari contributes significantly to the development, revision, and improvement of courses, curricula, and programs. Examples include developing and substantially revising several senior electives and graduate-level face-to-face and online courses, including Additive Manufacturing, Quality Engineering, Experimental Design in Engineering, Lean Manufacturing, and Production Planning.

These courses are very popular and highly subscribed, which reflects Tewari's passion for continuously improving courses. To make his courses more applied and the student learning more active, he incorporates projects based on industry, research, and hands-on manufacturing process simulation.

The ME-EM department credits Tewari's teaching with increasing students' interest in obtaining a minor in manufacturing. In the past nine years, the number of students completing the minor has quadrupled. His dedication and efforts also led to the creation of the Graduate Certificate in Quality Engineering. This has become the most popular graduate certificate among those offered by ME-EM.

Tewari also served as co-advisor of Innovative Global Solutions, one of the student teams in Michigan Tech's Enterprise Program. IGS students create affordable solutions for developing countries via research, design, analysis, prototypes, testing, and refining.

Tewari's research background is highly interdisciplinary, with research experiences in the applied sciences focused on implantable medical devices, micro and nano biosensors, mechanical

micromachining and microfabrication, semiconductor fabrication technologies, and micro and nano metrology and characterization tools.

Tewari coordinates the ME-EM Graduate Seminar Series, inviting distinguished speakers known nationally and internationally in academia, industry, and government.

In addition to being an esteemed professor, Tewari is an alumnus. He earned his MS and PhD in mechanical engineering at Michigan Tech in 2007 and 2014, respectively, after working in the manufacturing sector as a production engineer at Bajaj Auto Limited in India. He earned his bachelor's degree in mechanical engineering from the Maulana Azad National Institute of Technology in India.

APSRC BECOMES INDEPENDENT MTU RESEARCH CENTER

The Advanced Power Systems Research Center (APSRC, also called APS LABS) is now a fully independent research facility. As of July 2, 2021, the APSRC functions separately from the ME-EM department and continues to be managed by Director Jeff Naber, Associate Director Jeremy Worm, and Director of Business Operations and Finance Lauren Beastall.

ME-EM faculty are among the 71 Michigan Tech faculty and staff who participate in APSRC research. During fiscal year 2023, APSRC focused on continuing to build partnerships to continue research and funding in key areas and to build new partnerships and funding through diversification. This included leveraging the US Department of Energy Solar Regional Test Center (RTC) for new partnerships and awards, and working closely with the State of Michigan, the Michigan Alliance for Greater Mobility Advancement, and nongovernment organizations (NGOs) for training and skills development. The APSRC also received its first major research award from the US Department of Defense.

NUCOR METROLOGY CENTER OPENS

On September 20, 2022, the ME-EM department officially opened the Nucor Metrology Center with a donor appreciation event recognizing Nucor Corporation for its generous support of the facility.

University and department officials also recognized Milwaukee Tool and Nexteer for their equipment donations to the center.

"We thank Nucor for their very generous donation of $100,000 to establish the Nucor Metrology Center in the ME-EM department here at MTU," said Jason Blough, department chair. "We would also like to thank Milwaukee Tool, Nexteer, and Richard Crosby '56, owner/president of Winn-Dixi Machine Tools, for their assistance in enhancing the capabilities of the facility. Industry support has always allowed us to offer outstanding experiences to our students and to grow our research portfolio and capacity in ways that would not otherwise be possible."

"Huskies are ready to tackle the next problem and help create the future with innovative solutions," said Katie Amar-Fox '19, melt shop metallurgist at Nucor. "Nucor is excited to be a part of expanding the on-hand and lab experiences with the funds for the metrology lab. We believe that powerful partnerships create powerful results and are looking forward to these partnerships for years to come."

The Nucor Metrology Center provides students with the resources to make highly accurate measurements for their project components, advancing the Michigan Tech College of Engineering's objective to provide world-class undergraduate and graduate education to support a diverse workforce and societal needs.

"We want to see our students use their hands for physical engineering, and that happens in measurement," said Rachel Store '16 '17, Michigan Tech assistant teaching professor (MMET) and former head of the Nucor Metrology Center.

"The students will take data to document their product performance, all while better understanding their product quality through metrics."

Store says the center gives students exposure to the equipment they will see in industry when they graduate. "We know familiarity and fluency strengthen their hands-on, intensive experience," she said. "Confidence is built on reality."

The lab features both traditional and leading-edge, industry-standard equipment, including calipers, micrometers, a flexible arm coordinate-measurement machine (CMM), optical microscope, microhardness testers, tachometers, strobometers, and infrared and thermal scanners.

"Nucor's donation allowed us to purchase a Leica DVM6 motorized digital microscope and a Hexagon Metrology absolute measurement arm, giving us the ability to do high-quality metrology measurements for part inspection," said Blough. "We are already using this technology in one of our research programs and in one of our undergraduate courses."

2022-2023

NEW FACULTY

AMIR **HUSSAIN IDRISI**

Dr. Amir Hussain Idrisi recently joined the ME-EM department as an assistant teaching professor. He earned a PhD in Mechanical Engineering from United Arab Emirates University, and an MS in CAD-CAM and BS in Mechanical Engineering, both from Uttar Pradesh Technical University in India. His research interests include metal matrix and polymer matrix composites, including fabrication techniques, and physical and mechanical characterization, as well as additive manufacturing, internal crack analysis in metal or composite components, relating process conditions to static and dynamic mechanical properties, and upcycling. He brings over five years of teaching experience at SRMS College of Engineering and Technology in India.

VINH **NGUYEN**

Dr. Vinh Nguyen joined the ME-EM department in fall 2022 as an assistant professor. He came to Michigan Tech from the National Research Council, where he worked as a postdoctoral fellow at the National Institute of Standards and Technology. He earned a PhD in Mechanical Engineering and an MS in Mechanical Engineering and Electrical and Computer Engineering at the Georgia Institute of Technology, and a BS in both Mechanical Engineering and Electrical Engineering from Rensselaer Polytechnic Institute. His research focus is on advanced sustainable manufacturing; Industry 4.0; human-robot machine interaction; physics-based, data-driven modeling; and industrial automation, including autonomous vehicles and industrial robotics.

Dr. Ye Qi joined the ME-EM department in fall 2022 as an assistant teaching professor, bringing substantial experience in determining surface mechanical and material properties to Michigan Tech. She earned a PhD in Mechanical Engineering from the Georgia Institute of Technology, and both an MS in Mechanical Design and Theory and BS in Mechanical Engineering and Automation from Beijing Jiaotong University. Qi's research focuses on tribology. She develops new techniques for modifying the surface of cutting tools, including shot peening with mechanochemical modifications, electrical discharge machining, and friction and wear characteristics of surfaces textured via laser beam machinery.

YE **QI**

SHANGYAN **ZOU**

Dr. Shangyan Zou '18 joined the ME-EM department in fall 2022 as an assistant professor. He came to Michigan Tech from the Pacific Marine Energy Center at Oregon State University, where he worked as a postdoctoral researcher in the Department of Civil and Construction Engineering. He also completed postdoctoral research at Iowa State University in the Department of Aerospace Engineering. Zou earned a PhD in Mechanical Engineering at Michigan Tech in 2018. His research interests include dynamics and control with applications to ocean renewables, multi-agent systems (autonomy), machine learning, optimization, and state estimation. He has a strong interest in making renewable energy more economically viable.

ME-EM AND MACHINE LEARNING

Associate Professor Hassan Masoud (bottom left) and students at work in the Complex Fluids and Active Matter Lab. Clockwise from top left: Robert (RJ) Slater, Kevin Li, Umar Mustafa, and Muhammad Usman.

A KALEIDOSCOPE OF RESEARCH APPLICATIONS

Machine learning, abbreviated ML, is the process of using mathematical methods to help a computer learn on its own.

ML has become the most pervasive and powerful form of artificial intelligence, or AI, used to provide the logic behind computers.

ML techniques behind AI have been rapidly evolving over the past 10 years. This is especially the case with generative AI, a subset of ML that generates information in the form of text, images, or other media.

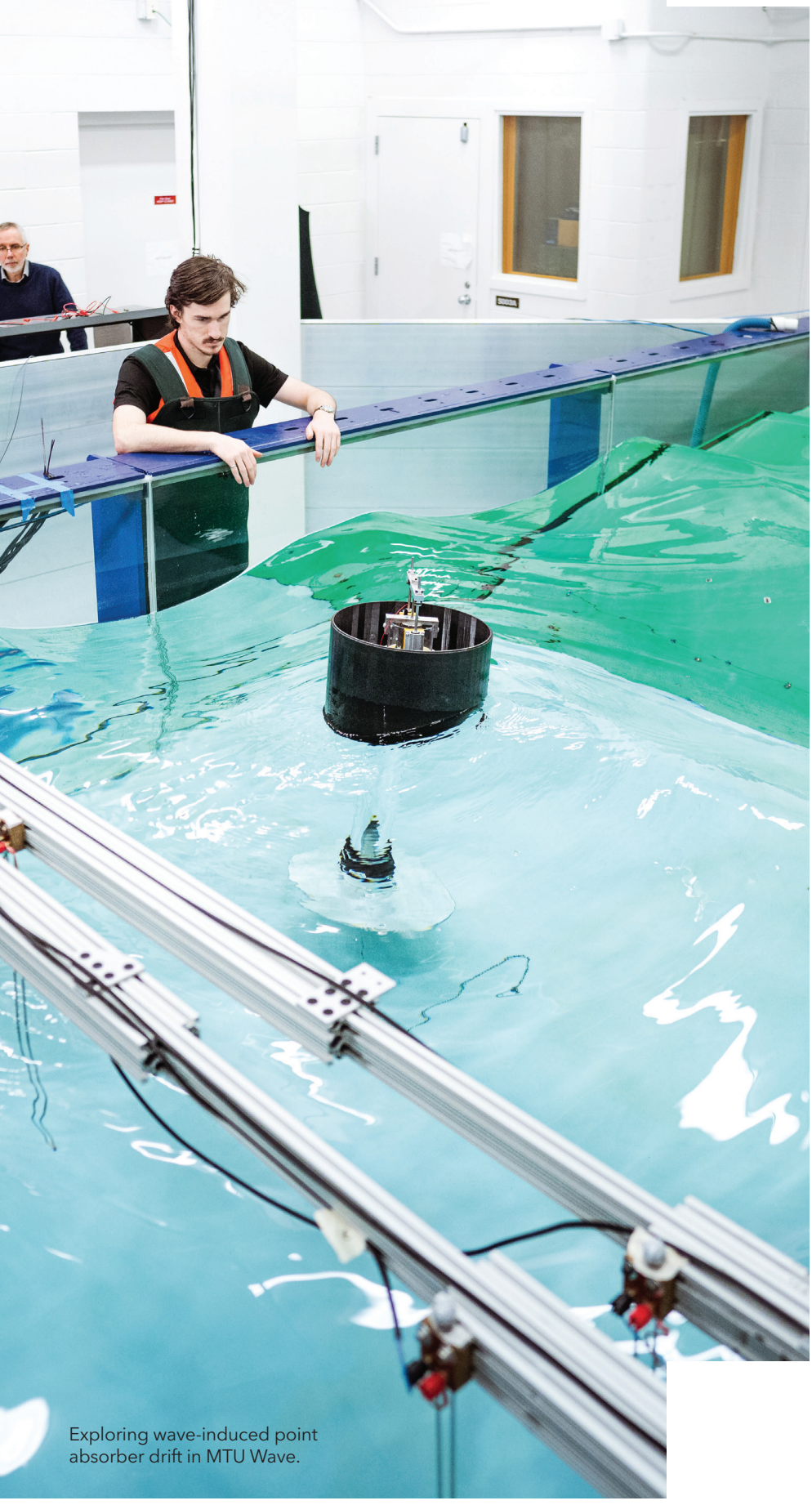
However, ML has been around for much longer than its recent advancements suggest.

A system that used algorithms and technologies to sift through a dataset, identifying patterns and making informed decisions based on inferences, was demonstrated in the 1950s.

At Michigan Tech, ME-EM faculty and students employ a wide range of ML methods (physics-informed, reinforcement learning, generative, classification, etc.) in various applications, from assessing student learning to marine energy and computational nanomechanics.

All seem to agree: ML can be useful, vital, and transformative, but it's not foolproof. It has limitations—and risks.

This compilation highlights some of the ways ME-EM faculty are using ML to advance research and learning at Michigan Tech.



Exploring wave-induced point absorber drift in MTU Wave.

GORDON PARKER: *CONTROL SYSTEMS*

Professor, John and Cathi Drake Endowed Chair in Mechanical Engineering

"Our students are developing skills to make good choices of when to use ML and when not to."

Gordon Parker wants to determine the force of a wave on a buoy several seconds before it happens to control energy extraction. He and his collaborators—including MS students Morgan Kline, Mandy van Wieren, Vasu Bhardwaj, Houssein Yassin, and Luke Schloemp—are using ML to reach that goal.

"We use reinforcement learning for wave energy converter (WEC) control and neural networks for estimating wave forces," he explains.

To obtain initial data, Parker and his research team have two sources: numerical models, usually constructed in Simulink; and experiment data from MTU Wave, the University's collaborative wave tank laboratory.

"Our goal is to be predictive—for example, determining the force of a wave on a buoy several seconds before it happens," he says. "It's also prescriptive. With WEC control, we apply the control signal to the WEC so that energy extraction occurs."

His view on ML? "We get the best results when ML is applied to dynamic systems that we understand well," he says. "Controlling a WEC using ML works best when we exploit what we know about its dynamic response. Working with subject matter experts to frame the ML solution is essential for success."

LEARN MORE

SHANGYAN ZOU '18: *WAVE ENERGY CONVERSION*

Assistant Professor, Mechanical Engineering-Engineering Mechanics

"Remarkably, reinforcement learning is model-free—it can learn unknown optimality via direct interaction with the environment."

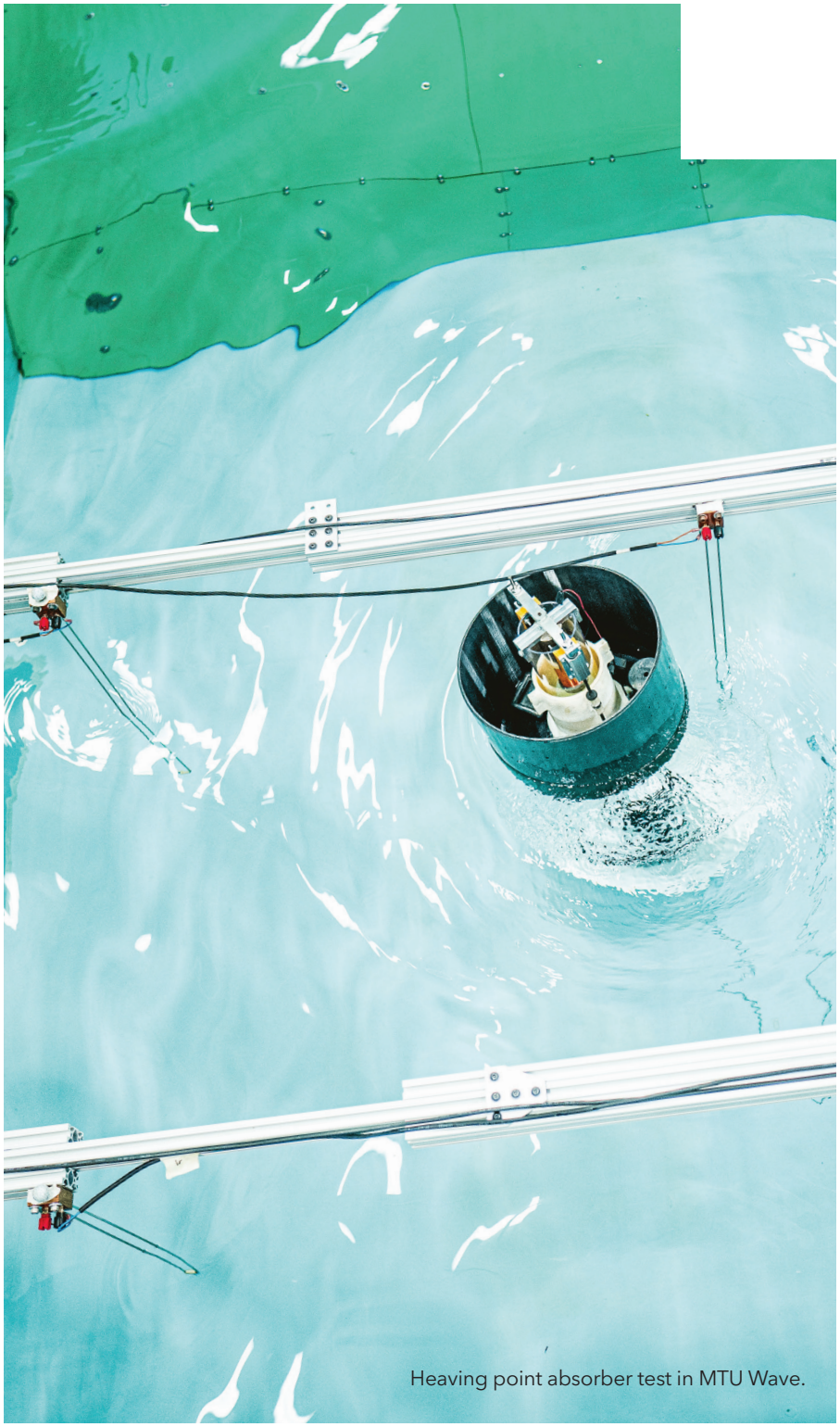
In his studies of wave energy conversion systems, Shangyan Zou has replaced model-based controls with alternatives based on reinforcement learning, a type of ML.

"A wave energy converter system is highly nonlinear and complex—especially when you consider its behavior from wave to wire," he says. "Many challenges need to be addressed in order to make wave energy practical and viable. In particular, power takeoff control is crucial. Effective power takeoff control (PTO) enables a wave energy converter to harvest power efficiently."

To improve PTO control, traditional research efforts have focused on developing advanced model-based controls. But despite their promising performance in numerical simulations, Zou finds the practical performance of these models "questionable."

Seeking a remedy, Zou turned to ML, using training data from his research team's own simulations of wave energy systems. He has spent a little over a year developing an algorithm for reinforcement learning control, with promising—even startling—results.

"Remarkably, the reinforcement learning control does not need an explicit knowledge of the system dynamics. It's model-free but can learn unknown optimality via direct interaction with the environment," he says. "This feature makes the reinforcement learning control optimal, adaptive, and robust when subject to a complex and constantly changing ocean environment."



Heaving point absorber test in MTU Wave.

VINH NGUYEN: *INDUSTRY 4.0*

Assistant Professor, Mechanical Engineering-Engineering Mechanics

"I see inherently fundamental flaws in machine learning that cannot be brute-forced with 'add more data.'"

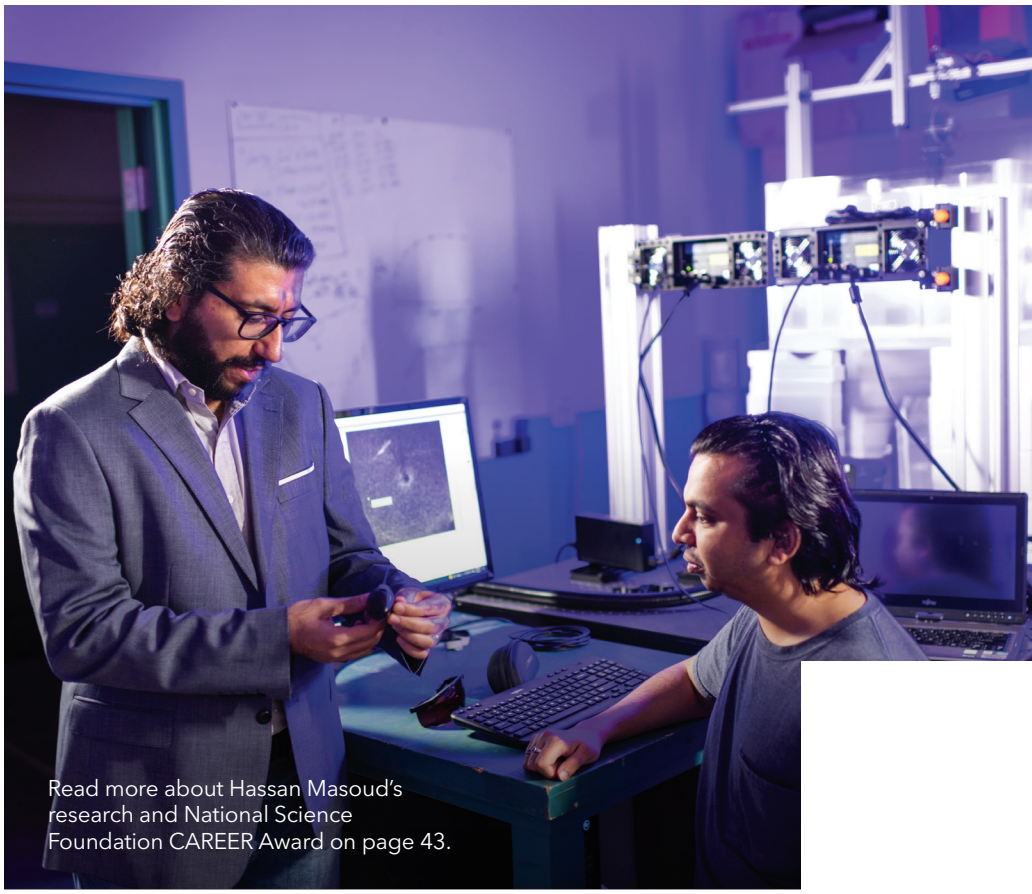
Vinh Nguyen wants to help manufacturers use ML. He and his team are developing ways to automatically prepare data for use as inputs for ML models, so that even manufacturing engineers with little knowledge of ML—or data processing, or data handling and cleaning—can develop and deploy their own accurate ML models.

"Rather than applying machine learning methods, I develop machine learning approaches for advanced manufacturing applications, including methods to explain multimodal models to manufacturing operators," he explains. "This involves simultaneous data in different formats, such as images, text, and acoustics."

"We obtain our initial data by conducting experiments in the ME-EM Computer Numerical Control (CNC) lab," he adds. "For additive manufacturing, we use publicly available datasets. We also collect our own metal additive manufacturing data at Michigan Tech."

Nguyen has used ML in his work for the past seven years. "It's a useful tool in a tool chest, along with many other tools," he says. On the other hand, he is aware of its limitations. "I see inherently fundamental flaws in machine learning that cannot be brute-forced with 'add more data,'" he states—and he sees additional downsides. "As with any tool, people can become too reliant on the output of the machine learning model rather than critically thinking alongside the model."

Nguyen imagines one more: "When ML is used for generative design, a nefarious actor could hack the machine learning model to compromise the design in such a way a team of engineers wouldn't recognize—especially as designs become more complex."



Read more about Hassan Masoud's research and National Science Foundation CAREER Award on page 43.

HASSAN MASOUD: *COLLECTIVE LOCOMOTION*

Associate Professor, Mechanical Engineering-Engineering Mechanics and Affiliated Associate Professor, Mathematical Sciences

"The risk involves using ML tools for solving problems that can actually be tackled using classical approaches much more efficiently."

Hassan Masoud wants to uncover the simplicity underlying complexity. He uses applied mathematics and experiments to solve problems in his Complex Fluids and Active Matter Lab at Michigan Tech, where he studies the collective motion of swimming fishlike robots and insect-inspired robotic surfers.

"I use the tools of machine learning and artificial intelligence to identify robust strategies for optimum collective locomotion, including how to maximize the amount of useful information extracted from flow visualization experiments," he says. "It's something we've done for the past three years, using initial data from our own experimental measurements."

Previously, Masoud used neural network modeling to show how a supervised ML approach could deduce the direction of the free-stream flow, based on deformation signals output by synthetic hair sensors arranged in a closed-pack array.

"I expect machine learning and artificial intelligence to continue to be an important part of my research toolbox," he says. "I see them as tools to solve optimization and inverse problems, which are encountered regularly in the field of mechanical engineering."

SUSANTA GHOSH:
GENERALIZED ML TOOLS FOR MATERIALS MODELING

Assistant Professor, Mechanical Engineering-Engineering Mechanics

"Anywhere you have a lot of data to learn from, you can use machine learning."

Susanta Ghosh wants to reduce the cost of materials design, accelerate computational nanomechanics, and improve the detection of breast cancer. In just five years, he has succeeded in all three areas.

"Materials scientists and engineers use density functional theory, or DFT, to understand, predict, and design the properties of materials, especially for the efficient and reliable computation of ground-state properties in condensed matter systems," Ghosh explains. The problem is, DFT is currently too expensive to use in large-scale materials simulations involving high numbers of atoms. "We use machine learning to overcome this computational bottleneck, and have met with great success," he says. Ghosh's team obtains data from collaborators at UCLA who perform large-scale DFT simulations using high performance computing (HPC).

Ghosh's team has developed an interpretable ML model that can accurately predict the complex deformations of nanomaterials. "A multiwalled carbon nanotube is made of millions of atoms," he notes. "Our model accurately matches an atomistic-physics-based model while being orders of magnitude faster. The teams generate training data with an in-house computational mechanics code and HPC."

Ghosh's group also uses ML and publicly available annotated data from real patients to improve the accuracy of breast cancer image classification. "ML models have enormous potential in the field of medicine," says Ghosh. "For our part, we develop Bayesian neural network models for medical image classification. We then seek to quantify uncertainties in their prediction. Going further, we use the uncertainties obtained by the Bayesian neural network to improve the network's performance on a large subset of data. Then we provide an explanation for these uncertainties by performing a nonlinear dimensionality reduction of the image data."

Their result: "We have shown that Bayesian networks can perform better than the state-of-the-art machine learning models—that's in addition to quantifying uncertainties," says Ghosh. "In medical applications, quantifying uncertainties in ML decisions should be given the utmost importance."

"One key limitation of ML models is their lack of generalizability," says Ghosh. His team creates ML models that overcome this issue, working beyond the known dataset. His group also focuses on determining how much uncertainties are present in the predictions of ML models. In addition to the basic predictions, the quantified uncertainties help the user in decision-making using ML.

SOME COMMON ML TERMS

Machine learning is a field filled with big data—and technical terms such as these:

Blackbox or Mystery Box
A type of ML model that provides a result with no explanation or insight into the system's process. Only the algorithm itself knows how the result was generated.

Whitebox
A type of ML model that provides a result and explains the process by which the answer was reached.

Supervised Learning
Use of labeled datasets to train algorithms to classify data or predict outcomes accurately. As input data is fed into the model, the model adjusts its weights until it has been fitted appropriately.

Unsupervised Learning
When algorithms analyze and cluster unlabeled datasets, discovering hidden patterns or data groupings without the need for human intervention.

Reinforcement Learning
Similar to supervised learning, but the algorithm isn't trained using sample data. This model learns as it goes by means of trial and error.

Foundation Model
A large ML model trained on a vast quantity of data at scale (often by self-supervised learning or semi-supervised learning) such that it can be adapted to a wide range of downstream tasks.

Sources:
IBM, ibm.com/topics/machine-learning
Wikipedia, en.wikipedia.org/wiki/Foundation_models

JIM DE CLERCK '09: *ENGINEERING EDUCATION*

Professor of Practice, Mechanical Engineering-Engineering Mechanics and Faculty Advisor, Formula SAE Enterprise

"I encourage students to use generative AI to enhance learning, rather than replace learning."

Jim De Clerck wants to help students write better use cases. "A key part of the engineering design process involves first identifying user needs and then translating those qualitative needs into actionable and measurable engineering requirements," he says. "To do that translating, we ask our students to write a first-person narrative story, something we call a use case."

De Clerck says a good use case explains how a particular user interacts with a system or machine to accomplish a task or achieve a goal. It should clearly describe—both qualitatively and quantitatively—user needs and goals, specific points that impede achieving those goals, and a vision of the result after implementing an optimal solution.

"I now encourage our students to use AI tools like Bard or ChatGTP to kick-start their creative writing process for developing a use case," he says. "They can do this by providing an initial description of the user role, the environment, and the task to be accomplished. Once AI generates the framework, our students then add specific details."

Encouraging students to employ AI for use case writing came up during a faculty work group discussion De Clerck had with Dr. Bill Endres and Dr. Aneet Narendranath just a few months ago. "We were talking about how students struggle to write good use cases, with subsequent ineffective use in their design projects."

The act of writing a use case helps an engineer better understand the needs of the user roles, adds De Clerck. "My goal is to help students to use generative AI with good intentions—and to see it as a tool that can allow them to focus more of their brain power on engineering thinking," he says. "My prediction is that once an engineer learns to use AI to accelerate and enhance the quality of their writing, it will become indispensable, much like grammar check and spell check."

JEFF NABER: *ELECTRIFIED VEHICLES*

Richard and Elizabeth Henes Endowed Professor (Energy Systems), Mechanical Engineering-Engineering Mechanics

"Machine learning helps us determine where in the planned drive a vehicle should use either electric or gas mode in order to minimize the total energy used. Our data comes from physical testing of vehicles. We have a set of highly instrumented vehicles funded under the Tech Forward initiative and available for use by the University community. Data is collected from thousands of signals and can be recorded dynamically over extended driving periods (hours). This creates rich datasets for multiple activities."

In general, Jeff Naber and his team want to reduce vehicle energy consumption. In particular, they're working to optimize how plug-in hybrid electric vehicles use battery-stored electrical energy based on variations in their drive cycle—including distance, speed, traffic, and more. This research is part of Michigan Tech's US Department of Energy ARPA-E NEXTCAR project, which Naber directs.

Over many years in research and development, Naber and his team—including PhD student Andrew Robare—have used ML for the prediction and control of engines, powertrains, and vehicles.

"ML is an important tool in our toolbox that we regularly use in concert with other analysis and modeling methods," he notes. "A benefit of machine learning is its ability to identify patterns from large datasets. This is useful for predicting complex variables and states where the physics are complex, with many interacting factors, and also difficult and computationally expensive to predict."

Nonetheless, says Naber: "Domain knowledge is critical. Understanding how a device or system works remains important."

SRIRAM MALLADI: *VIBRATIONS*

Assistant Professor, Mechanical Engineering-Engineering Mechanics

"ML can be used to better understand physics, but it's not a tool that replaces physics."

Sriram Malladi wants you to imagine the sounds heard during an airline flight. "Have you noticed a different noise profile during takeoff, midway, and while landing?" he asks. The difference is caused by acoustic foam that isolates passengers from the source of the sound. Here at Michigan Tech, Malladi and his research team are using ML to develop a lighter-weight alternative that's also more effective.

Using ML reinforcement learning techniques, Malladi and his team are developing a self-learning sound insulation system that adaptively absorbs vibrations based on the noise generated by the source. "We're creating 'vibration black holes' using meta-structure," he explains. "On moving these black holes, we've discovered numerous parameters that can't be handled when incorporating adaptive and active components. So we're using reinforcement learning to obtain a solution in real time."

"ML is indispensable for data analytics, data-driven models, and data compression. Blackbox models aren't as interesting. That's because if we know something can be modeled, but we don't know the reason for it, then we can't use machine learning for broader applications," he says.

His bottom line: "Students must learn math rigorously in order to develop the necessary skills to apply ML tools appropriately. It's easy to use ML, just as when we turn on Netflix and select from show suggestions. Yet underlying this is a physically descriptive mathematical framework. I want students to understand that math, rather than blindly applying ML tools."

ANEET NARENDRANATH '13: *LEARNING ASSESSMENT*

Associate Teaching Professor, Mechanical Engineering-Engineering Mechanics

"With assistance from machine learning, we can accurately and quantitatively assess highly unstructured data traces of learning."

Aneet Narendranath wants to support students with data-driven insights and nuanced feedback. "While communicating technical results, what students say and how they say it is a common dimension across our curriculum, and all curricula," he says. "What is untapped is the knowledge that within a student's communications are hidden markers of learning, engagement, and metacognition—the awareness of one's own thought process."

Narendranath and his team are working to identify and extract these hidden markers, to better understand a student's evolving strengths. For the past two years, they have applied machine learning—and, more recently, large language models that power generative AI tools like Bard and ChatGPT—along with complex dynamical systems knowledge, linguistics, statistical methods, and learning theories.

For initial data, the team taps an abundance of spoken and written communication that exists in the public domain. In particular, Narendranath points out that YouTube has billions of spoken language data points. "The site is commonly used in initial forays and testing of machine learning embodied methods," he says. "Modern-day computational linguistics tools have training and validation datasets built from publicly available data from YouTube, Reddit, Twitter, the BookCorpus, IMDB reviews, and Project Gutenberg."

The team has access to student technical communication artifacts, collected as part of their routine assessment process. "This latter data is only admitted retrospectively into our research after the proper Institutional Review Board and data compliance requirements are correctly and carefully met, to protect student privacy," he explains.

The result thus far? "We have found that we can accurately assess student communication artifacts to identify and measure the strengths of essential thematic elements," says Narendranath. The team drew upon 350 essays across two semesters, analyzing over 500,000 words and nuanced combinations of words. "It would not have been feasible to perform the analysis without ML support," he notes. "We showed the realization of the desired effect of a course refinement, by measuring the strengthening of a thematic element."

STEVEN MA: *AUTONOMOUS LAWN MOWER*

Professor of Practice, Mechanical Engineering-Engineering Mechanics

"Like a human being, a machine can be taught to learn from the images put in front of it. Machine learning can be accurate, fast, and reliable. As a tool, it can greatly improve our quality of life."

Steven Ma wants you to imagine your lawn mower no longer needs help.

"My research is on autonomous wheeled vehicles—specifically and recently, an autonomous lawn mower," he says.

"I use machine learning to identify objects such as grass, sidewalk, trees, bushes, fence, and pavement. I also use machine learning to segment the work areas and avoid obstacles, like a tree, rabbit, or human."

ML turned out to be helpful for path planning, too. "The entire project took about three years, with our initial data coming from Google Maps images and self-taken photos."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FINDING THE POWER TO

SUSTAIN COLD-CLIMATE COMMUNITIES

Energy systems are transitioning at the same time that weather and climate are changing. Ana Dyreson works at this intersection, specifically focusing on how these concurrent shifts impact the Great Lakes Region.

When approaching the interconnected global challenges of energy and climate change, it's crucial to zoom in on the regional picture, says Dyreson, assistant professor of mechanical engineering-engineering mechanics and leader of the Great Lakes Energy Group.

"Every region has its own characteristics," she says. "If we don't explore those in each unique region, we won't understand the drivers for each region. We won't have the right solutions."

Dyreson, who grew up on the family farm in Portage, Wisconsin, can trace her interest in how society manages energy back to childhood. Her work remains centered in the region she calls home and includes projects on consideration of lake-effect climate, electrification of heating services, snow shading on solar photovoltaics, and the energy-generation potential of wind and waves on the lakes themselves.

Dyreson's examination of the impact of weather, climate, and climate change on future power systems is rooted in energy engineering, from analysis to interconnected built and natural environments. But community connections are just as important as selecting and implementing the optimal infrastructure. In order for low-carbon electrification to be successful in the long run, the pathway there must be both technically feasible and socially acceptable. To involve community stakeholders, Dyreson's work includes many interdisciplinary research themes that address the best foundational practices for post-industrial sustainable development.

LARGE-SCALE IMPACT ACROSS THE REGION

In 2022, Dyreson was awarded a $499,445 grant from the Alfred P. Sloan Foundation for a project, "Electrification and Climate Resilience in the Rural North: Challenges and Opportunities." It aims to assess both the opportunities for resilient electrification of space heating and cooling in rural northern areas of the Upper Midwest and the technical and social barriers standing in the way. She leads an interdisciplinary team focused on three community-engaged case studies: in Baraga County, Michigan; Ashland and Iron counties in Wisconsin; and Minnesota's Beltrami and Clearwater counties.

Also in 2022, Dyreson and her Great Lakes Energy Group began research on single-axis tracking systems for photovoltaic solar power as part of a project led by Sandia National Laboratories and funded by the US Department of Energy's Solar Energy Technologies Office. The research,

which uses energy analysis and grid-scale modeling, is taking place in the US Department of Energy's Michigan Solar Regional Test Center (RTC). The center operates out of Michigan Tech's Advanced Power Systems Research Center (aka APS LABS), adjacent to the Keweenaw Research Center. It's the northernmost of five RTCs, all managed by Sandia, established to evaluate the performance and reliability of emerging photovoltaic (PV) technology. In late 2022, Array Technologies, a research collaborator at the RTC, installed a 10-row, 33-kilowatt, grid-tied, single-axis-tracking solar PV system. "This project is currently industry relevant and we're really happy to have a partner," says Dyreson.

"The system Array Tech installed roughly doubled the center's footprint, providing a foundation for observational studies led by both Michigan Tech and company research teams as we look for ways to improve system operation in cold and snowy climates," says Dyreson. The environment, with plentiful and reliable snowfall, is ideal for the study of snow shedding off solar panels. While snow likely sheds faster off panels with a tracking system that moves them throughout the day to keep them facing the sun, little is known about the performance of tracking systems in snowy climates.

"We really don't know how well they drop snow, what times of day, what times of events. And that's why our research has become more focused on that," Dyreson says.

IMPACT OF SNOW SHADING ON GRID OPERATIONS

As part of the University's Initiative on Sustainability and Resilience (ISR), Dyreson was one of three researchers selected as Sustainable and Resilient Communities Faculty Research Fellows charged with developing new collaborations and increasing research activities. She also led the effort, through the Michigan Tech Research Excellence Fund (REF), to create a dataset that targeted key research topics at the energy-water-climate nexus in the Upper Midwest.

"Improving PV system operation in cold climates improves cost-effectiveness and ultimately addresses one of the biggest challenges in climate change and sustainability: reducing the carbon intensity of electricity supply," says Dyreson. "The hardy and enterprising mindset that we apply to solutions—as well as life in the wintry Keweenaw—serves us well as we take on this formidable task."

PROJECT TIMELINE

Phase	Target	Task
1	Winter 2023	Analyze relationship between snowy states and utility solar growth.
2	Spring 2023	Collect adequate snow data. What regions? Separate from rain? Climate change impacts?
3	Summer 2023	Create model to estimate the impact of snow on solar power plants. Must consider climate region, panel types, and temperature. This phase will include designing, writing, and testing the code.
4	Fall 2023	Run electricity grid simulation, which will quantify the impact of snow on grid behavior.

Other recent projects involving Dyreson and Great Lakes Energy Group include:

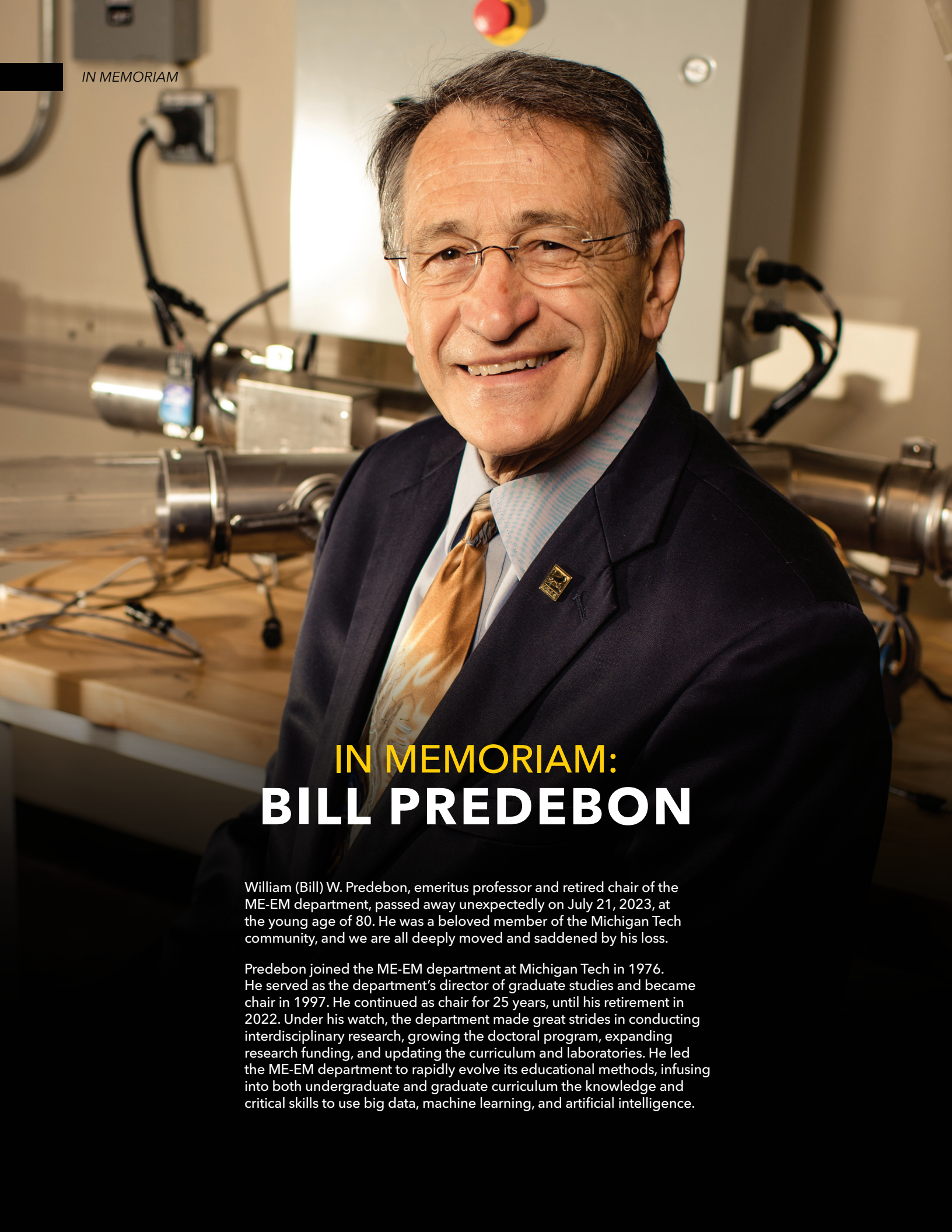
- "Incorporating climate impacts into electricity system planning models," a Power Systems Engineering Research Consortium (PSERC) endeavor running from July 2022 to August 2024. Includes researchers from multiple universities.

- "Mackinac Marine EV Solutions," focused on clean electrification of ferries in the Straits of Mackinac. The $100,000 study was funded in the first round of grants via the Michigan Mobility Funding Platform in cooperation with Michigan's Office of Future Mobility and Electrification and the Department of Environment, Great Lakes, and Energy. The study ran from September 2021 to August 2022 and included Michigan Tech's Great Lakes Research Center and APS LABS, as well as the Mackinac Economic Alliance and Mackinac Marine Services.

- A dedicated educator, Dyreson welcomes talented PhD students to the Great Lakes Energy Group. Two of them, Shelbie Wickett and Ayush Chutani, are responsible for important aspects of the ongoing research at the RTC located in the Keweenaw Peninsula. Chutani hopes to develp new algorithms using a sensor system he installed last winter. The sensors will be used for new smart controls on the single-axis tracking systems that will adjust panel positions before, during, or after observed snow. Wickett, who is earning her PhD remotely through Michigan Tech's program option, worked on simulating how a grid with high amounts of utility solar installations behaves during snow scenarios, incorporating a snow-shedding model into the grid simulation.

“The hardy and enterprising mindset that we apply to solutions—as well as life in the wintry Keweenaw—serves us well as we take on this formidable task.”

Ana Dyreson, Assistant Professor, Mechanical Engineering-Engineering Mechanics



IN MEMORIAM: BILL PREDEBON

William (Bill) W. Predebon, emeritus professor and retired chair of the ME-EM department, passed away unexpectedly on July 21, 2023, at the young age of 80. He was a beloved member of the Michigan Tech community, and we are all deeply moved and saddened by his loss.

Predebon joined the ME-EM department at Michigan Tech in 1976. He served as the department's director of graduate studies and became chair in 1997. He continued as chair for 25 years, until his retirement in 2022. Under his watch, the department made great strides in conducting interdisciplinary research, growing the doctoral program, expanding research funding, and updating the curriculum and laboratories. He led the ME-EM department to rapidly evolve its educational methods, infusing into both undergraduate and graduate curriculum the knowledge and critical skills to use big data, machine learning, and artificial intelligence.

Predebon grew up in New Jersey and earned his bachelor's degree in engineering science from the University of Notre Dame in 1965. During his undergraduate years, he met his future wife of 56 years, Mary Ann Montgomery, and served in the US Army/ROTC as a commander of the Irish Marauders Drill Team. Upon graduation he was commissioned as a lieutenant, and he would eventually be promoted to captain.

Predebon received both his master's and doctorate from Iowa State University. While pursuing his degrees, he and Mary Ann married and had two children, Nadine and Bill Jr. After earning his PhD, Predebon was stationed at Aberdeen Proving Ground in Maryland, where he fulfilled his military obligation and stayed on as a civilian until 1975. At that point, Bill and his family moved to Houghton, where he took a job as a professor at Michigan Tech.

Predebon's research in ceramics, computational modeling and simulation of impact phenomena, and explosive fragmentation was supported by the National Science Foundation, the US Department of Defense, and other government agencies and industrial partners. He had more than 40 publications and held two US patents.

A Fellow of the American Society of Mechanical Engineers (ASME), Bill received numerous additional honors at MTU, including membership in the Academy of Teaching Excellence, the Outstanding Service Award for his work with the student chapter of the Society of Automotive Engineers, the first annual Martin Luther King Award given by the Black Students Association, and the Distinguished Faculty Award from the Michigan Association of Governing Boards of Colleges, as well as the Distinguished Teaching Award, the Honorary Alumni Award, and the Diversity Award. In 2019, he was inducted into the Pan American Academy of Engineering, which brings together engineers from across 18 countries.

Predebon led efforts to create the Michigan Tech Learning Resource Center for Self-Paced Programmed Instruction and the ME-EM Engineering Learning Center. He was also central in establishing a distance learning doctorate degree in mechanical engineering and a Design Engineer Certificate program with General Motors in 2000. More than 600 GM employees earned the certificate. In 2010, Predebon started a Peace Corps Master's International program in mechanical engineering at Michigan Tech, the first and only one of its kind in the nation.

Predebon was a captain in the US Army Reserves and a member of four honor societies: Tau Beta Pi (engineering), Phi Kappa Phi (academic excellence), Omicron Delta Kappa (leadership), and Theta Tau (engineering). He advised both the Nordic and Alpine ski teams and Delta Sigma Phi fraternity, and chaired building committees for both the Dow Environmental Sciences and Engineering Building and the Great Lakes Research Center.

Bill was passionate about whatever he did, whether it was his strong work ethic, his family, or his devotion to faith. Throughout his life, his curiosity fueled the continued pursuit of knowledge. He is and will continue to be greatly missed.

Bill Predebon is standing in the back row on the left.

MULTIPLANETARY INNOVATION ENTERPRISE (MINE)

Michigan Tech currently has 23 Enterprise teams on campus working to pioneer solutions, invent products, and provide services. In the Planetary Surface Technology Development Lab (PSTDL), members of the Multiplanetary INnovation Enterprise (MINE for short) design, test, and implement robotic technologies for extracting and using local resources in extreme environments—including the moon and Mars, as well as flooded subterranean environments here on Earth.

Assistant Professor Paul van Susante helped launch the team, and serves as MINE's faculty advisor. The team's three ongoing projects are Lunabotics, DIVER, and TRENCHER.

MINE team members build and test robotic vehicles and technologies for clients in government and the private sector. They tackle construction and materials characterization, too.

Mechanical engineering student Parker Bradshaw is a member of both MINE and the PSTDL, where he works with van Susante as an undergraduate researcher. Bradshaw is preparing a research paper detailing data the team has gathered while excavating in the lab's Dusty Thermal Vacuum Chamber (DTVAC), with a goal of sharing what was learned by publishing their results in an academic journal.

In the lab, students work in the DTVAC and simulate lunar conditions through operation of the giant vacuum chamber—a facility created by van Susante that, among universities, is almost unique to Michigan Tech. It's a vacuum-sealed room, partially filled with a simulated lunar dust, that can be cooled to minus 196 degrees Celsius and heated to 150 degrees Celsius—essentially, a simulated moon environment. In the chamber, researchers can test surface exploration systems (i.e., rovers) in a box containing up to 3,000 pounds of regolith simulant. It's about as close to moon conditions as one can get on Earth.

Bradshaw is one of the ME-EM students working on the Trencher, a proof-of-concept for mining the lunar surface using a bucket ladder-style excavator.

"Bucket ladders offer a continuous method of excavation that can transport a large amount of material with minimal electricity, an important consideration for operations on the moon," Bradshaw says. "With bucket ladders, NASA will be able to extract icy regolith to create rocket fuel on the moon and have a reliable method to shape the lunar surface."

Unlike soil, regolith is inorganic material that has weathered away from the bedrock or rock layer beneath. The Trencher is a series of buckets on a chain that spins around in an oval

shape. Placed into the ground, the Trencher continuously excavates the regolith out of the ground and into a collection system.

Regolith is a huge challenge to operating on the moon. The dustlike material gets into and on every surface and limits the amount of time astronauts have to conduct their missions. With the Trencher project, students conduct field tests using an Earth environment similar to lunar regolith: the Keweenaw stamp sands. And the PSTDL's specialized facilities allow them to take their tests one step further by replicating the cold vacuum of space.

As the Trencher scoops up regolith inside the chamber, students measure how much dust they were able to collect and the power consumption used in the process. The results have been published in an academic journal and students presented them at an academic conference last year.

SENIOR DESIGN:
CASCADE CHILLER

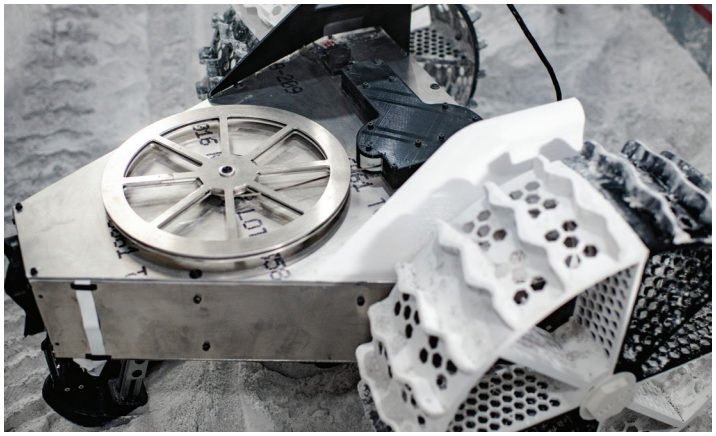
Michigan Tech's Senior Design program connects students and industry through challenging projects that have an open-ended design solution. As part of this capstone option, each small team of students works together on a project that serves as their top priority throughout senior year.

A faculty advisor for each team provides the right balance of instruction and coaching to facilitate learning by doing. Teams have access to state-of-the-art design and collaboration tools, as well as dedicated fabrication facilities, labs, and design studios. Senior Design functions more like a first job than a last class, providing the kind of relevant design experience that can launch new engineers into a rewarding, successful career.

In spring 2023, ME-EM seniors built a cascade fluid chiller intended to accept a fluid from an external process and cool it to cryogenic temperatures as low as minus 122 degrees Fahrenheit. This type of chiller has demand in both lab environments for cryogenic storage as well as other chemical processes requiring cryogenic temperatures. The students are seeking to improve upon reliability issues associated with an auto-cascade system currently on the market. The project was supported by industry sponsors Fluid Chillers Inc. and Cleveland Cliffs.

LEARN MORE

Members of the Cascade Chiller Senior Design team included Hunter Bondy, Sean Munro, Bode Salmeto, Grant Fiet, and George Darbyshire, all mechanical engineering majors. The team was advised by Robert Page, ME-EM's laboratory facilities manager.



BIG Idea teams took on near-term technology capability requirements to support NASA's exploration objectives for permanently shadowed regions (PSRs) in and near the moon's polar regions. T-REX, short for the Tethered permanently-shadowed Region EXplorer, is MTUengineering's award-winning prototype designed to lay down lightweight, superconducting cable connected to a lander. Once the rover reaches its final spot after traversing rocky crater terrain into the PSRs, the rover can serve as a recharging hub and communication relay for other robots, providing continuous power without direct sunlight.

MARCELLO GUADAGNO

Today, Marcello Guadagno's CV is flush with advanced degrees, publication credits, and impressive internships. He is a PhD candidate and a key member of a Michigan Technological University lab that has won multiple awards in national design competitions hosted by NASA. He was also recently awarded a prestigious Science, Mathematics, and Research for Transformation (SMART) Scholarship from the US Department of Defense (DoD).

But when Guadagno first arrived at Michigan Tech in 2014, he could not have pictured any of this. His vision for his future was, like that of many first-year students, blurry at best.

Marcello Guadagno

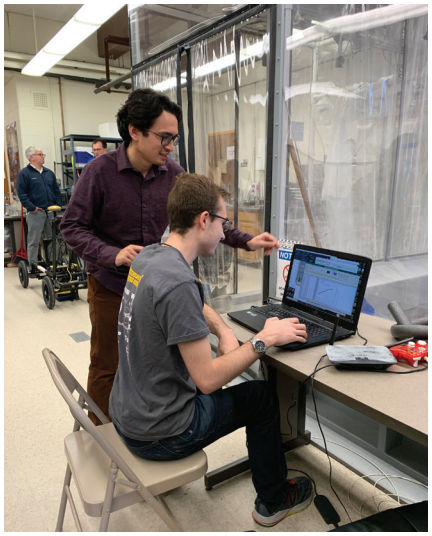
Guadagno found his place at Tech on Michigan Tech Aerospace, an Enterprise team where he helped build satellites and other spacecraft, gaining experience he would later parlay into positions with NASA, Orbion Space Technology—a Houghton-based aerospace company specializing in plasma propulsion systems—and others. Through those experiences and his mechanical engineering coursework, he made his way into the Planetary Surface Technology Development Lab (PSTDL) led by Assistant Professor Paul van Susante.

Guadagno has been a leader in the PSTDL ever since, working on a variety of projects critical to NASA's Artemis missions to support sustainable human exploration of the moon's surface. The team participates in many of NASA's Centennial Challenges, like the Watts on the Moon Challenge, which tasked teams from around the country with designing new technologies for storing, distributing, and managing energy for use throughout the lunar day/night cycle. Guadagno and the PSTDL team began exploring lunar power management through their participation in the 2020 NASA BIG Idea Challenge, where they devised a network of tethered rovers to navigate the uncertain terrain and deliver power via superconducting cables. After winning the Artemis Award in that competition, they enhanced and expanded their design for the Watts challenge. They are among four finalist teams now competing for the $1 million grand prize.

"My passion was always working on projects and building cool things," Guadagno says. "So it was really nice having the Aerospace Enterprise and Paul's lab, both of which let me direct my passion in a way that not only gives me class credit, but helped me build up a resume and a breadth of project experience on real things that actually exist—and in some cases, have actually gone to space."

The DoD SMART Scholarship that Guadagno recently received is part of

"Looking back, it was really fun to be able to shape my future and get to where I am today—getting my doctorate and going into the aerospace field—using the resources that were available in the ME-EM department and at the University in general."



the National Defense Education Program, which builds future leaders in 24 STEM disciplines by giving recipients hands-on experience at DoD facilities during their internships and early career. For Guadagno, the SMART Scholarship will include full tuition and an education-related expenses payment, a generous stipend and allowance, summer internships, health insurance, and mentorship and employment placement at the Kirtland Air Force Base in New Mexico. There, he will be working on experimental spacecraft payloads in the Air Force Research Labs Space Vehicle Directorate.

It's the zenith of a long journey for the once-undecided first-year engineering major.

"One of the most gratifying experiences at Tech has been meeting all these smart, intelligent people along the way and being able to stay in contact with them," Guadagno says. "It's really nice seeing all the people and friends that I've met, learning where they are now, and being able to talk with them and work on projects together with them."

$5.4 MILLION FEDERAL COOPERATIVE AGREEMENT WILL SUPPORT MICHIGAN TECH STUDENT AND FACULTY RESEARCHERS

In a five-year $5.4 million cooperative agreement, Michigan Technological University has joined the National Institute of Standards and Technology Professional Research Experience Program (NIST PREP).

The NIST PREP agreement will support Michigan Tech undergraduate students and graduate students—including international students—as well as faculty affiliates. The program provides valuable laboratory experience and financial assistance. Fellowships are awarded to assure continued growth and progress of science and engineering in the United States.

"Opportunities to work as a NIST PREP Fellow—conducting cutting-edge research under the advisory of a NIST sponsor—are open to any discipline or major," says Vinh Nguyen, assistant professor in the Department of Mechanical Engineering-Engineering Mechanics and NIST PREP coordinator at Michigan Tech.

"This is an excellent opportunity for researchers at Michigan Tech and NIST to get connected for short-term collaborations and long-term partnerships. We are very fortunate to have this unique opportunity for our students."

Greg Odegard, Professor and John O. Hallquist Endowed Chair in Computational Mechanics and NIST PREP Manager

Nguyen worked as a National Research Council Postdoctoral Fellow at NIST from 2020 to 2022, just prior to joining the faculty at Michigan Tech. "There are many fields in standards and measurement where NIST and Michigan Tech have aligned research activities, including microelectronic fabrication, safe AI, and environmental conservation. This partnership has the potential to significantly advance NIST's mission in promoting US commerce while promoting synergies amongst NIST and Michigan Tech personnel," he says.

One of the nation's oldest physical science laboratories, NIST was founded in 1901 and is now part of the US Department of Commerce. NIST measurements support the smallest of technologies to the largest and most complex of human-made creations—from nanoscale devices so tiny that tens of thousands can fit on the end of a single human hair up to earthquake-resistant skyscrapers and global communication networks.

Greg Odegard, John O. Hallquist Endowed Chair in Computational Mechanics in the ME-EM department, is the NIST PREP manager. Odegard sees potential for growth and increased funding over time. "This is an excellent opportunity for researchers at Michigan Tech and NIST to get connected for short-term collaborations and long-term partnerships. We are very fortunate to have this unique opportunity for our students," he says.

For graduate students, support includes full stipend and full tuition. Undergraduate students receive co-op support. At Michigan Tech, Jeff Allen serves as NIST PREP undergraduate advisor. He is associate chair and John F. and Joan M. Calder Endowed Professor in Mechanical Engineering-Engineering Mechanics. Additionally, Wayne Weaver will serve as Michigan Tech's NIST PREP graduate advisor. He is a ME-EM department associate chair and director of graduate studies.

"With the prestigious NIST award, MTU is poised to empower scholars who will act as catalysts, wielding influence to guide our society through the transformative currents of the 21st century, ultimately forging a brighter tomorrow for all of humanity," says Wayne Gersie, former vice president for diversity and inclusion at Michigan Tech. Gersie, who was also a research assistant professor of cognitive and learning sciences at Tech, contributed to writing the proposal.

MICHIGAN TECH IS A NIST PREP INSTITUTION

NIST advertises available researcher positions through its network of PREP universities. PREP researchers must be affiliated with a participating university.

This program offers opportunities for MTU students and faculty to collaborate with NIST researchers.

While based in the ME-EM department, this agreement provides University-wide opportunities in areas such as communications technology, engineering, information technology, material measurement, and physical measurement.

Michigan Tech joins the following NIST PREP universities:

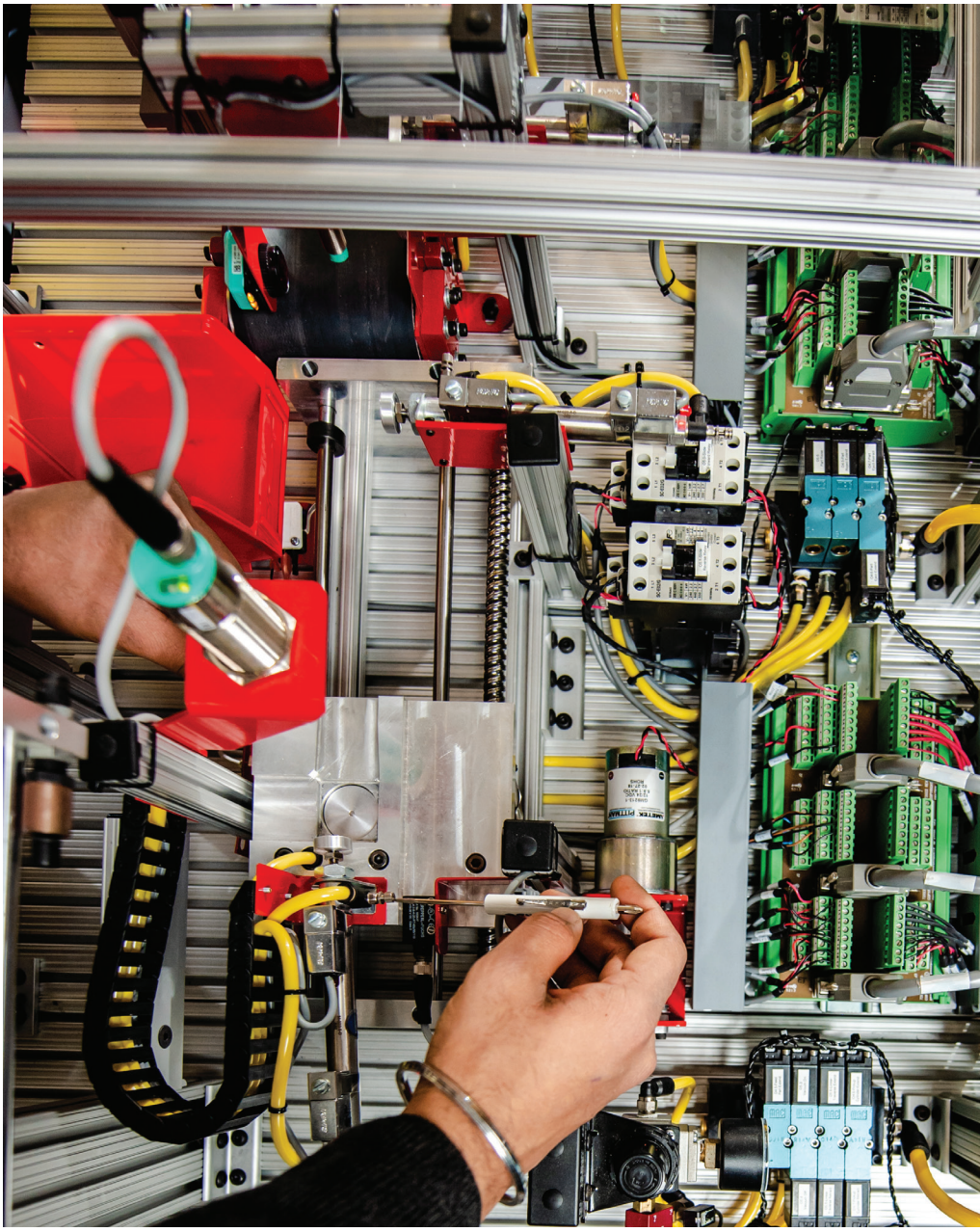
- Morgan State University
- Johns Hopkins University
- The State University of New York Binghamton
- Bowie State University
- University of Maryland Eastern Shore
- Coppin State University
- Tuskegee University
- North Carolina Agricultural and Technical University
- Georgetown University
- Michigan Technological University
- George Washington University
- University of Maryland College Park
- Montgomery College
- University of Colorado Boulder
- University of Colorado Denver
- New Mexico State University
- Colorado School of Mines

A few positions recently posted: Metrics for Human-Robot Interaction for a postgraduate student; Decision Science for a postdoctoral economist or social scientist; and Front End Web App Developer for a postbaccalaureate student. Positions are either part-time at 20 hours a week or full-time at 40 hours per week.

Though the PREP opportunities are initiated by NIST personnel, Michigan Tech faculty are invited to propose a research opportunity of their own that aligns with the NIST mission and skillset. "For instance, Michigan Tech faculty can engage with NIST personnel and discuss potential PREP opportunities and fellows in the field of quantum optics on nanoscale platforms," says Nguyen.

"Michigan Tech's NIST PREP team will host regular information sessions for faculty and students, or they can reach out to me with any questions," he adds.

NIST PREP fellows and researchers work in a wide range of fields, including computing, biology, environmental health, nanofabrication, and robotics. They gain practical experience in calibration, standards, and measurement science, as well as professional and career development from MTU and NIST advisors, which happens through a NIST PREP Individual Development Plan.



WOMEN IN STEM

HANNAH STOLL '19 '20

The ME-EM department is proud to feature students, alumni, and other community members on our blog every week for Women in STEM Wednesday at Michigan Tech. If you would like to nominate someone for Women in STEM Wednesday, please email Donna Jeno-Amici (djenoami@mtu.edu) or Meg Raasakka (mraasakk@mtu.edu).

Q: Where are you from?
HS: Lansing, Michigan. I currently live in the Twin Cities working for SICK Sensor Intelligence as a test systems engineer.

Q: Degrees and graduation years?
HS: I earned a BS in Mechanical Engineering in 2019, and an MS in Electrical Engineering in 2020.

Q: What do you do for fun?
HS: I joined a beginner hockey league through AHA with a friend, and I sub in a sand volleyball league, too. I also spend my time 3D printing, playing video games, creating models and graphics online, hanging out with friends and family, and camping.

Q: Fun fact, pets, and favorite quote?
HS: I am an only child! No pets yet, sadly. "You miss 100 percent of the shots you don't take." —Wayne Gretzky

Q: Why did you choose Michigan Tech?
HS: I chose MTU to play college basketball, to enjoy the beautiful Copper Country and its community, and to go to an impressive engineering school.

Q: Favorite places near campus?
HS: I have two: Houghton's waterfront trails and the covered road on the way to Copper Harbor.

Q: What do you like most about Tech?
HS: I love the area. The people are just like family. The Pep Band is amazing and creates an atmosphere like no other for all sporting events. At Tech, everyone has a place to feel welcome—and a great opportunity to excel and prepare for the future.

Q: How has Tech impacted your view of STEM?
HS: Michigan Tech showed me how many different areas of STEM there really are and how fun it can be to dig into those topics. There is no getting bored, as there is plenty to learn. STEM also has so many great career opportunities!

Q: What originally interested you in STEM?
HS: I've always enjoyed messing around on the computer, building things, and knowing how stuff works.

Q: What piece of advice would you give your younger self?
HS: Get into programming sooner because it could have made my life a lot easier in school.

Q: What advice would you give students interested in STEM?
HS: I would tell them to ask their peers and professors about real-world applications and focus on what interests them, because it will help them go in the right direction to find a job they really like in the future! PS—The hard work is really worth it!

Q: What do you want to do to change the world?
HS: I will continue working with new and upcoming technologies to advance our industries, and to make an impact on future generations.

ME-EM EXCELS
AT NATIONAL ASME/SME COMPETITION

A team of recent mechanical engineering graduates won third place in the 2023 ASME/SME Student Manufacturing Design Competition. Dante Cardinali, Jake Holwerda, Jack Pluta, and Connar Christensen competed against seven other teams in the final stage of the competition, held June 13 at the 2023 Manufacturing Science and Engineering Conference (MSEC) hosted by Rutgers University.

The annual contest is a forum for students to share ideas, supports interest in manufacturing, and provides the manufacturing community with fresh perspectives on design. Cardinali, Holwerda, Pluta, and Christensen competed against universities including Harvard, Northwestern, University of California-Davis, and University of Michigan to advance to the finals.

"It's an impressive feat for our students to earn third place," says ME-EM Assistant Professor Vinh Nguyen, who served as the team's advisor throughout the competition. "They performed well under pressure due to their experience working in real-world environments at Michigan Tech."

The team's project for an improved camshaft delivery system was created as part of ME-EM's Senior Design program, a capstone option connecting students and industry through challenging projects with an open-ended design solution. The students' industry client, CWC-Textron, asked the team for help improving the safety and efficiency of its Hemi camshaft line.

"We strive to give students an experience much more like their first job than their last class," says Bill Endres, Richard and Elizabeth Henes Professor, Mechanical Engineering-Engineering Mechanics. "We also highly emphasize situational understanding at the early stage of solution development, so the students gain an understanding of the people involved and the problems they battle."

"The CWC-Textron team did a fantastic job in that regard," Endres adds. "Their solid understanding of the problem and of those in production who would work with their solution led to a highly functional, yet very simple result. And that's not an easy combination."

Camshafts are subjected to extreme conditions during use. As part of CWC-Textron's manufacturing process, the camshafts are subjected to the selectively austempered ductile iron (SADI) process to increase their mechanical properties. SADI castings are treated in a quick quench bath of molten salt. This can purposefully cause buildup that impacts the reliability of the hatch, allowing for further testing and analysis.

The end result? Using SADI, Michigan Tech students developed a solution for a reliable hatch opening system with reduced risk to operators. Benefits included reduced downtime and an increase in worker safety.

Every student on the team graduated in spring 2023. Dante Cardinali went on to complete a summer manufacturing engineering internship in Muskegon and plans to earn his MBA at Madonna University. Jake Holwerda now applies his knowledge and skills at JOST International as a product engineer. Jack Pluta is working as a process engineer at Excel Engineering in Fond du Lac, Wisconsin, while pursuing an online master's in engineering management at Michigan Tech. Last but not least, Connar Christensen is now a quality engineer for Kohler Co. in Dallas, Texas.

WHO'S HIRING MICHIGAN TECH
ME-EM GRADUATES

- 3M
- A&B Packing Inc.
- Accelerate Wind
- Alithya Fullscope
- Amcor
- American Orthodontics
- Andronaco Inc.
- Arctic Cat
- Artiflex Manufacturing LLC
- Asama Coldwater Manufacturing
- Associated Spring
- AVL in North America
- Axiom Space
- Bemis Manufacturing Company
- Black & Veatch
- Blattner Energy
- Broken Spoke Bike Studio
- Brunswick Corporation
- BW Papersystems
- BWI
- Calumet Electronics Corporation
- Captive Aire
- Caterpillar
- Century A&E
- CG Bretting
- Cleveland-Cliffs
- Collins Aerospace
- Consumer Energy
- Cummins Inc.
- Dakkota Integrated Systems
- Dematic
- US Department of Defense
- DEVCOM GVSC
- Doosan Bobcat North America
- Douglas Machine Inc.
- E & E Manufacturing
- Eck Industries Inc.
- EDAG Group
- Enstrom Helicopter Corporation
- Epic Systems
- EQI Ltd.
- Excel Engineering Inc.
- Flexfab
- Fluid Motion LLC
- Ford Motor Company
- Fortna Inc.
- Foth Production Solutions LLC
- GE Aerospace
- General Dynamics Land Systems
- General Electric (GE)
- General Motors
- Gentex
- Georgia Pacific
- Gerdau
- GS Engineering
- Halla Mechatronics
- Hanon Systems
- Harley-Davidson Motor Company
- Hemlock Semiconductor
- Honda
- HS Inc.
- Husco
- Hussey Seating Company
- Hydraflex
- Innotec
- James Hardie
- Jervis Webb
- JR Automation
- KBR Inc.
- Kiln Technology
- Kimberly-Clark
- Kohler Co.
- Koppers Performance Chemicals
- Kyyba Inc.
- Lake Superior Consulting
- LDRA Limited
- Leco Corporation
- Leidos
- LexaMar
- Linamar
- Marion Body Works Inc.
- McMahon
- McNeilus
- Mercury Marine
- Meritor
- Michael Best & Friedrich LLP
- Michigan Air Products
- Michigan Tool Technology
- Miller Electric Mfg. LLC
- Milwaukee Tool
- MIT Lincoln Laboratory
- Modine Manufacturing
- MTU Department of Materials Science and Engineering
- MTU Advanced Power Systems Research Center (APS LABS)
- Naval Nuclear Lab
- Navistar
- Neuvokas Corporation
- Nexteer Automotive
- Northrop Grumman
- Nucor Steel
- OHM Advisors
- Omni Metalcraft
- Orbion Space Technology
- Oshkosh Corporation
- Oshkosh Defense
- P & A
- PCA
- Penn Engineering and Manufacturing
- Pfizer
- Pierce Manufacturing
- Pipeline Design & Engineering LLC
- Plexus Corp.
- Polaris Inc.
- Profil
- Seagrave Fire Apparatus

#1

Ranked No. 1 public college in Michigan and second in the nation for salary impact (Wall Street Journal)

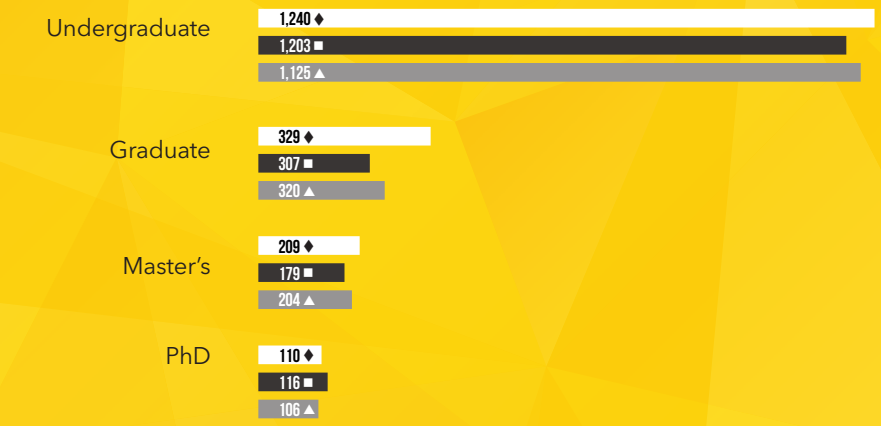
Top 25

Included in the Top 25 Colleges for Your Money based on return on investment (Forbes)

- Sebright Products Inc.
- Shape Corporation
- Sierra Space
- Skilled Manufacturing
- Snap-on Incorporated
- Steelcase
- Techtronic Industries
- Temple Controls
- Tesla
- The Boeing Company
- Tiara Yachts
- Tokyo Electron US
- Holdings Inc.
- Tower Solutions LLC
- US Navy Officer Programs
- Uchiyama Marketing and
- Development
- UL Solutions
- Universal Creative
- Verso
- Vista Outdoor
- Voith Meri Environmental
- Solutions
- Voith Paper
- Webasto Group
- Wes-Tech Automation
- Solutions
- WestRock Company
- Whirlpool Corporation
- Williams International
- Winchester Interconnect
- Wold Architects and
- Engineers
- Woodward Inc.
- Xcel Energy
- ZF North America Inc.

BY THE NUMBERS

Enrollment



Enrollment Totals: 20-21: 1,569 | 21-22: 1,510 | 22-23: 1,445

Degrees Awarded

MASTER'S DEGREES

SUMMER 2022 (10)

Gadekar, Shreyas Suhas
Advisor: Sriram Malladi
An Experimental Study Towards Underwater Propulsion System Using Structure-Borne Traveling Waves

Ilenich, Matthew
Advisor: Wayne Weaver
Coursework only

Jupalli, Sai Anish Reddy
Advisor: Wayne Weaver
Coursework only

Kemppainen, Joshua D.
Advisor: Gregory Odegard
Coursework only

Mrozinski, Robb M.
Advisor: Wayne Weaver
Coursework only

Nair, Aditya Kalidas
Advisor: Wayne Weaver
Coursework only

Paprocki, Carter A.
Advisor: Sriram Malladi
Characterization of Hydraulic Flow Noise Induced by Spool Valves

Pathare, Ajinkya Janardan
Advisor: Wayne Weaver
Coursework only

Stanchina, Zachary J.
Advisor: Jeffrey Naber
An Experimental Study of Fuel Selection for a Gasoline Multi-mode, Spark Ignited-Compression Ignition Engine

Strong, Christiana T.
Advisor: Parisa Abadi
Coursework only

FALL 2022 (31)

Bale Gopichand, Akhilesh
Advisor: Wayne Weaver
Coursework only

Chaudhari, Piyush Hitendra
Advisor: Wayne Weaver
Coursework only

Gadag, Ganesh Ishwar
Advisor: Wayne Weaver
Coursework only

Galapure, Abhilash B.
Advisor: Wayne Weaver
Coursework only

Goodenough, Bryant
Advisors: Darrell Robinette and Jeremy Worm
Coursework only

Jadhav, Karan Prabhakar
Advisor: Wayne Weaver
Coursework only

Johnson, George B.
Advisor: Wayne Weaver
Calorimetric Measurements Of Lunar Regolith Simulant And Water. An Experimental Study Correlating Weight Percent Water And Temperature Change Through Periods Of Phase Change

Kashmari, Khatereh
Advisor: Gregory Odegard
Coursework only

Kirantu, Madhava
Advisor: Wayne Weaver
Coursework only

Lin, Edward
Advisor: Wayne Weaver
Coursework only

Madhavan, Rohith
Advisor: Wayne Weaver
Coursework only

Madugula, Akhil
Advisor: Wayne Weaver
Coursework only

Maity, Sagnik
Advisor: Wayne Weaver
Coursework only

Mali, Rajeev Hanmant
Advisor: Wayne Weaver
Coursework only

Marni, Venkata Rayudu
Advisor: Wayne Weaver
Coursework only

Martin, Kelsey A.
Advisor: Wayne Weaver
Coursework only

McFall, Madeleine R.
Advisor: Wayne Weaver
Coursework only

Miller, Jonathan
Advisor: Leonard Bohmann
Coursework only

Nelson, Kevin J.
Advisor: Gordon Parker
Optimal Control of Nonlinear Wave Energy Converters in Heave for Maximum Power Extraction

Panchal, Ronak Jagdishchandra
Advisor: Wayne Weaver
Coursework only

Patel, Meet Pankaj
Advisor: Wayne Weaver
Coursework only

Pendyala, Shandilya
Advisor: Wayne Weaver
Coursework only

Rachakonda, Ganapathi Sai Karthik Sathvik
Advisor: Wayne Weaver
Coursework only

Rathore, Adesh
Advisor: Wayne Weaver
Coursework only

Rupnar, Yuvraj Babasaheb
Advisor: Wayne Weaver
Coursework only

Shaha, Shubham Pravinkumar
Advisor: Wayne Weaver
Coursework only

Suriya Narayanan, Karthik
Advisor: Wayne Weaver
Coursework only

Swain, Himanshu Kumar
Advisor: Wayne Weaver
Coursework only

Tendulkar, Umesh Prashant
Advisor: Wayne Weaver
Coursework only

Uthirakumar, Siddharth
Advisor: Wayne Weaver
Coursework only

Yakes, Austin T.
Advisor: Wayne Weaver
Coursework only

SPRING 2023 (67)

Alapatt, Jerome Kurien
Advisor: Wayne Weaver
Coursework only

Avasare, Abhijit Rajendra
Advisor: Wayne Weaver
Coursework only

Balaji, Srivaths
Advisor: Wayne Weaver
Coursework only

Bhate, Jimit Jagdish
Advisor: Wayne Weaver
Coursework only

Boyini, Roopesh Kumar
Advisor: Wayne Weaver
Coursework only

Challa, Nihal Reddy
Advisor: Wayne Weaver
Coursework only

Chinchoriya, Praneet Sitaram
Advisor: Wayne Weaver
Coursework only

Chinmula, Harish Reddy
Advisors: Wayne Weaver
and Jason Blough
Coursework only

Dalvi, Atharv Eknath
Advisor: Wayne Weaver
Coursework only

Das, Sarbeswar
Advisor: Wayne Weaver
Coursework only

Deshmukh, Ajinkya Shrinivas
Advisor: Wayne Weaver
Coursework only

Deshmukh, Janak Narendra
Advisor: Wayne Weaver
Coursework only

Deshmukh, Mayur Ashok
Advisor: Wayne Weaver
Coursework only

Dhiman, Chanchal
Advisor: Wayne Weaver
Coursework only

Dhote, Tejas Nitin
Advisor: Wayne Weaver
Coursework only

Dsa, Marc Cajetan
Advisor: Wayne Weaver
Coursework only

Fahad Bin Sayeed Masqati, FNU
Advisor: Wayne Weaver
Coursework only

Fairbanks, Hyrum
Advisor: Wayne Weaver
Coursework only

Golinske, Joseph
Advisor: Wayne Weaver
Coursework only

Gunjal, Anurag Anil
Advisor: Wayne Weaver
Coursework only

Hemalla, Sreespandan Reddy
Advisor: Wayne Weaver
Coursework only

Jammalamadaka, Mahalakshmi Madhoolika
Advisor: Wayne Weaver
Coursework only

Karan, Chetan A.
Advisor: Wayne Weaver
Coursework only

Karmarkar, Aditya Prasad
Advisor: Wayne Weaver
Coursework only

Kaveri, Rajivgandhi
Advisor: Wayne Weaver
Coursework only

Kokate, Akash Kishor
Advisor: Wayne Weaver
Coursework only

Kolgaonkar, Chinmay Milind
Advisor: Wayne Weaver
Coursework only

Kulkarni, Renuka Subodh
Advisor: Wayne Weaver
Coursework only

Kulkarni, Shriprasad Bhalchandra
Advisor: Wayne Weaver
Coursework only

Kuznicki, Lucas, H.
Advisor: Wayne Weaver
Coursework only

Majethiya, Ajay Hasmukhbhai
Advisor: Wayne Weaver
Coursework only

Manne, Sai Charan
Advisor: Wayne Weaver
Coursework only

Mogili, Sampath
Advisor: Wayne Weaver
Coursework only

Muttepawar, Omkar
Advisor: Wayne Weaver
Coursework only

Naik, Nidhip Jasmin
Advisor: Wayne Weaver
Coursework only

Natarajan, Venkataramanan
Advisor: Wayne Weaver
Coursework only

Noe, Jason
Advisor: Paul van Susante
Coursework only

Ousdigian, Mark M.
Advisor: Trisha Sain
An Experimentally Validated Computational Model For The Degradation And Fracture Of Magnesium-Based Implants In A Chemically Corrosive Environment

Oza, Gnan Vipul
Advisor: Wayne Weaver
Coursework only

Pai, Satvik
Advisor: Wayne Weaver
Coursework only

Panchal, Haren Sunil
Advisor: Wayne Weaver
Coursework only

Pandher, Amanpreet Singh
Advisor: Wayne Weaver
Coursework only

Patil, Anket Mahadeo
Advisor: Wayne Weaver
Coursework only

Patil, Chaitanya Anant
Advisor: Wayne Weaver
Coursework only

Patil, Yugandhara Yuvraj
Advisor: Wayne Weaver
Coursework only

Rajopadhye, Shivani Sunil
Advisor: Wayne Weaver
Coursework only

Rama, Sai Krishna
Advisor: Wayne Weaver
Coursework only

Ramasamy, Shanmugam
Advisor: Wayne Weaver
Coursework only

Ramu, Mohan Raj
Advisor: Wayne Weaver
Coursework only

Sangawar, Sushant Sanjay
Advisor: Wayne Weaver
Coursework only

Sawant, Adesh Mangesh
Advisor: Wayne Weaver
Coursework only

Shelar, Alok Maruti
Advisor: Wayne Weaver
Coursework only

Sirivolu, Akhilesh
Advisor: Wayne Weaver
Coursework only

Soraruf, Nicholas, J.
Advisor: Wayne Weaver
Coursework only

Stadler, Sarah E.
Advisor: Wayne Weaver
Coursework only

Sufiyan, Ahmed, FNU
Advisor: Wayne Weaver
Coursework only

Tawde, Rajat Rajendra
Advisor: Wayne Weaver
Coursework only

Tekawade, Shubham Maruti
Advisor: Wayne Weaver
Coursework only

Thakkalapally, Sai Krishna
Advisor: Wayne Weaver
Coursework only

Tyagi, Diwakar
Advisor: Wayne Weaver
Coursework only

Vishwakarma, Bhupendra Shashi
Advisor: Wayne Weaver
Coursework only

Vunkil, Himanshu Rao
Advisor: Wayne Weaver
Coursework only

Wagh, Ishan Sachin
Advisor: Wayne Weaver
Coursework only

Wangikar, Abhishek
Advisor: Wayne Weaver
Coursework only

Watpade, Ashitosh
Advisor: Wayne Weaver
Coursework only

Yadav, Amit Kumar
Advisor: Wayne Weaver
Coursework only

Yassin, Houssein
Advisor: Wayne Weaver
Coursework only

DOCTORAL DEGREES

SUMMER 2022 (5)

Alofari, Karrar Takleef
Advisors: Jeffrey Allen and Ezequiel Medici
Permeability, Structural Changes, Flow Regime Transitions in Fuel Cell Catalyst Layers and a Model for Predicting Trapped Saturation for Two-phase Flow in Porous Media

Ankith Ullal, FNU
Advisor: Youngchul Ra
Development of Advanced Models for Pre-Ignition Prediction in Gas Engines and Analytical Model for Wallfilm Evaporation

Deshpande, Prathamesh
Advisors: Gregory Odegard and Susanta Ghosh
Molecular Modeling of High-Performance Thermoset Polymer Matrix Composites for Aerospace Applications

Patil, Sagar Umesh
Advisors: Gregory Odegard and Susanta Ghosh
Molecular Modeling of High-performance Polymers

Yadav, Upendra
Advisor: Susanta Ghosh
Atomistic-Continuum Membrane and Machine Learning Models for Two-Dimensional Materials

FALL 2022 (10)

Ahmadi, Masoud
Advisor: Sajjad Bigham
Sorption-Based Dehydration Systems: Theory-to-Demonstration

Bayaniahangar, Rasoul
Advisor: Sajjad Bigham
3D-Printed Ceramic Volumetric Receivers: From Hierarchically-Ordered to Nature-Inspired High-Flux Solar Thermal Collectors

Egboiyi, Bennedict
Advisor: Trisha Sain
Fracture Mechanics of Chemically Strengthened Glass: Experiment and Modelling

Joshi, Satyum
Advisor: Jeffrey Naber
Concept Evaluation and Development of a Novel Approach for Integration of Turbogeneration, Electrification and Supercharging on Heavy Duty Engines

Okoh, Ikechukwu Emmanuel
Advisor: Sajjad Bigham
Advanced Thin-Film Sorption Thermal Energy Storage Systems for Thermal Load Shedding/Shifting

Pandhare, Rohit Sunil
Advisor: Hassan Masoud
Collective Hydrodynamics of Robotic Fish

Reddy, Gurijala Vankat Prithvi
Advisors: Darrell Robinette and Mahdi Shahbakhti
Design and Real-Time Implementation of Optimal Model-Based Torque Shaping Automotive Control Systems

Timm, Mitchel
Advisor: Hassan Masoud
Design and Analysis of Marangoni-Driven Robotic Surfers

Wiersma, Jeffrey
Advisor: Trisha Sain
A Coupled Viscoplastic-Damage Constitutive Model for Semicrystalline Polymers

Zoldak, Philip
Advisor: Jeffrey Naber
Partially Stratified Combustion of Natural Gas for Spark Ignition Engines

SPRING 2023 (5)

Batool, Sadaf
Advisors: Jeffrey Naber and Mahdi Shahbakhti
Dynamic Modeling and Control of a Multi-Mode Combustion Engine

Girdhar, Sunit
Advisors: Jason Blough and Andrew Barnard
Alternative Method for Low Frequency Impact Sound Measurement for Building Field Tests

Jacqueline, Frederic
Advisors: Jung Yun Bae and Darrell Robinette
Neuroevolution and Machine Learning Research Applied to Connected Automated Vehicle and Powertrain Control

Zhai, Jiachen
Advisor: Seong-Young Lee
Energy Analysis of Droplet Impingement on an Inclined Wall Under Different Temperature Environments

Zhao, Menghan
Advisor: Kazuya Tajiri
Study of Droplets Interactions on Solid Surface for Manufacturing Applications

FACULTY AWARDS AND HONORS

APRIL 2021 TO JUNE 2023

Dr. Parisa Abadi was selected by Michigan Tech's VP for Research Office as a recipient of a Fall 2021 Research Excellence Fund Award.

Dr. Jason Blough was the 2023 recipient of SAE International's Ralph K. Hillquist NVH Lifetime Achievement Award. This prestigious award recognizes Dr. Blough's exceptional contributions to ground vehicle noise, vibration, and harshness (NVH) for over 15 years.

Dr. Jason Blough, previously the vice president of the Society of Experimental Mechanics (SEM), assumed the role of president-elect in June 2023, and ultimately became president in June 2023.

Dr. Jim De Clerck was elected to serve as the president of SEM for a one-year term, which ended in June 2023. He will continue to serve as a past president for the next three years.

Dr. Ana Dyreson was selected by the Tech Forward Initiative on Sustainability and Resilience as a Sustainable and Resilient Communities Faculty Research Fellow in the realm of energy systems transitions and the energy-water-climate nexus.

Dr. Ana Dyreson was one of five panelists for the Sustainable and Resilient Communities Social Network and Research Collaborative (SRC-Squared) Panel Discussion on Resilience Research, hosted by the Tech Forward Initiative on Sustainability and Resilience.

Dr. William J. Endres was selected for the Richard & Elizabeth Henes Endowed Professorship–Senior Capstone (SCD) Program. This appointment recognizes the importance of the ME-EM SCD Program in our ME curriculum and, in particular, Dr. Endres' leadership in elevating the program to national prominence and one of the best in the US.

Dr. Susanta Ghosh was selected by Michigan Tech's VP for Research Office as a recipient of a Fall 2021 Research Excellence Fund Award.

Dr. Hassan Masoud received a $409,777 research and development grant from the National Science Foundation for his research project titled "CAREER: Collective Hydrodynamics of Robotic Swimmers and Surfers at High Reynolds Numbers."

Dr. Stephen Morse was the winner of the Mechanical Engineering Teacher of the Year Award for the 2021-22 academic year. The award is selected solely by mechanical engineering students and conducted by the Mechanical Engineering Student Advisory Committee.

Dr. Jeffrey D. Naber was selected for two Michigan Tech Awards. He received the 2022 Michigan Tech Research Award, selected by the VP for Research Office, and was also named the 2022 University Professor by the Office of the Provost and Senior VP for Academic Affairs.

Dr. Jeffrey D. Naber received the Vincent Bendix Automotive Electronics Engineering Award from the *SAE International Journal of Connected and Automated Vehicles* for 2020.

Dr. Aneet Narendranath was named an international scholar for the International Alliance to Advance Learning in the Digital Era (IAALDE) VISTAS Colloquium Series.

Dr. Myoungkuk Park was selected by Michigan Tech's VP for Research Office as the recipient of a Spring 2022 Research Excellence Fund Award.

Dr. Sheryl A. Sorby was named the recipient of the ABET 2021 Claire L. Felbinger Award for Diversity and Inclusion.

Dr. Paul van Susante was invited to be a panelist at the 168th meeting of the Aeronautics and Space Engineering Board in late 2021. He presented to the Infrastructure for Lunar Human Exploration panel.

Dr. Paul van Susante and members of his Planetary Surface Technology Development Lab (PSTDL), working as part of "Team Liquid," earned a runner-up award for Phase 1 of NASA's Break the Ice Lunar Challenge.

Dr. Paul van Susante received $2,200 for pre-college outreach and research seed programs from the Michigan Space Grant Consortium for its 2022-23 funding cycle, sponsored by NASA. His program is "Hands-On NASA-Oriented Experiences for Student Groups (HONES): 'Lunabotics Competition Robot.'"

Dr. Paul van Susante's PSTDL team's submission TEMPEST (Tethered Mechanism for Persistent Energy Storage and Transmission) was selected as a winner of Level 1 of NASA's Watts on the Moon Challenge Phase 2. The team received $200,000 and moved on to compete at Level 2.

Dr. Paul van Susante presented "Lunar In-Situ Resource Utilization to Unlock the Solar System" at the Earth, Planetary, and Space Sciences Institute (EPSSI) in November. Dr. van Susante discussed what payload to transport via moon and Mars missions to create sustainable space exploration and develop a thriving space economy, while opening up the solar system and bringing the unlimited energy and resources of space into the economic sphere of Earth.

DR. GREGORY M. **ODEGARD**

Dr. Gregory M. Odegard, director of the NASA Space Technology Research Institute (STRI), known as Ultra-Strong Composites by Computational Design (US-COMP), has been honored with a NASA Outstanding Public Leadership Medal. This prestigious award is granted to nongovernment employees who demonstrate remarkable leadership that significantly impacts NASA's mission. Leading a five-year collaboration involving 22 professors from 11 universities and two industry partners, Dr. Odegard oversees US-COMP's diverse expertise in molecular modeling, manufacturing, material synthesis, and testing. NASA recognized Dr. Odegard for his exceptional leadership and acknowledged the US-COMP team's invaluable contributions and service to both the agency and the nation.

Dr. Paul van Susante's PSTDL team was selected to advance TEMPEST to Level 3, the final stage of NASA's Watts on the Moon Challenge Phase 2. NASA's recognition marks a significant achievement for MTU's team, which received $400,000 to compete for the final $1.5 million prize.

Dr. Radheshyam Tewari was selected as the Mechanical Engineering Teacher of the Year for the 2022-23 academic year. The award is selected solely by mechanical engineering students and conducted by the Mechanical Engineering Student Advisory Committee.

Dr. Radheshyam Tewari was selected as the co-recipient of the 2023 Jackson Center for Teaching and Learning Instructional Award for Curriculum Development and Assessment based on his extensive and ongoing efforts to improve courses and curricula in the ME-EM department, including Additive Manufacturing, Quality Engineering, and Lean Manufacturing.

Dr. Jeremy Worm was reappointed by Governor Gretchen Whitmer to represent four-year universities on the Michigan Truck Safety Commission. His term began September 24, 2021, and expired August 4, 2023.

Dr. Yongchao Yang was selected to give the SEM 2023 SAGE Publishing Young Engineer Lecture, a keynote lecture that took place at the SEM IMAC Conference in Austin, Texas, in early 2023. The award recognizes "an SEM Member in early- to midcareer who demonstrates considerable potential in the field of experimental mechanics."

Dr. Yongchao Yang received the 2022 Achenbach Medal at the annual Stanford International Workshop on Structural Health Monitoring in Palermo, Italy. The annual award was created to recognize a young researcher who has made an outstanding contribution to the advancement of the field of structural health monitoring.

PATENTS AND PUBLICATIONS

BOOKS AND JOURNAL ARTICLES PUBLISHED
FROM JULY 1, 2022, TO JUNE 30, 2023

Note: **Bold author names** indicate ME-EM faculty members and *italicized author names* indicate current and past ME-EM students.

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2022 TO 2023

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We would also like to extend our gratitude to folks who, although not listed below, have supported various activities that benefit our students. Your donations, regardless of amount, make a significant impact on the lives of our students, faculty, and staff. Every dollar donated matters, and each of you is truly making a difference. Thank you!

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Ford Motor Company

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American Axle & Manufacturing Inc.
American Iron and Steel Institute
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CWC Textron
Deere & Company
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$1,000–$9,999
Barr Engineering Company
Beaumont Health System
Lake Effect Consulting Inc.
Milwaukee Electric Tool Corp.
SAE International
Sensors & Software Inc.
Voxel Science LLC
Whirlpool Corp.
World AutoSteel Association

$100–$999
Energy Management Services
Marathon Petroleum Company LP
Qualpro Strategies Inc.
SJ Kuehl LLC

Engineering Education Innovation

TITLE	NAME	SPONSOR	TOTAL PROJECT VALUE	PERIOD	
Student Design: Laser Drying Boost for Package Printing Applications	PI: William Endres	Paper Converting Machine Company	$6,000	Feb. 23, 2023	Dec. 31, 2024
Student Design: Cooktop Temperature Sensing	PI: William Endres	GHSP	$5,000	Sept. 12, 2022	July 31, 2023
Student Design: Improved Vacuum Sound for Pets	PI: William Endres	Bissell Homecare Inc.	$4,000	Sept.12, 2022	July 31, 2023
Student Design: Corrugated Hose Alternative	PI: William Endres	Bissell Homecare Inc.	$4,000	Sept. 12, 2022	July 31, 2023
Student Design: Floor Cleaner Lab Test Fixture	PI: William Endres	Bissell Homecare Inc.	$4,000	Sept. 12, 2022	July 31, 2023
Student Design: Variable Orientation Wet-Dry Separator	PI: William Endres	Bissell Homecare Inc.	$4,000	Sept.12, 2022	July 31, 2023
Student Design: Cordless Heated Mist Generation for Cleaning	PI: William Endres	Bissell Homecare Inc.	$4,000	Sept. 12, 2022	July 31, 2023
Student Design: Battery Pack Structural Design	PI: William Endres	John Deere Co.	$11,500	Sept. 12, 2022	July 31, 2023
Limited Sharing	PI: William Endres	Limited Sharing	$23,556	Feb. 1, 2023	Jan. 30, 2024
Student Design: High Voltage Battery Pack Cooling	PI: William Endres	Our Next Energy	$18,574	Jan. 9, 2023	Jan. 31, 2024
Student Design: Over-Fire Air CFD Modeling	PI: William Endres	Detroit Stoker Company	$15,479	Jan. 9, 2023	Jan. 31, 2024
Student Design: Portable Oxygen Concentrator	PI: William Endres	Valerie Obenchain	$9,286	Jan. 9, 2023	Jan. 31, 2024
Student Design: Closed Loop Laser Energy Control in Anilox Cleaning Applications	PI: William Endres	Paper Converting Machine Company	$9,286	Jan. 9, 2023	Jan. 31, 2024
Student Design: Laser Plate Cleaning	PI: William Endres	Paper Converting Machine Company	$9,286	Jan. 9, 2023	Jan. 31, 2024

Selected Grants and Contracts | 2023-2024

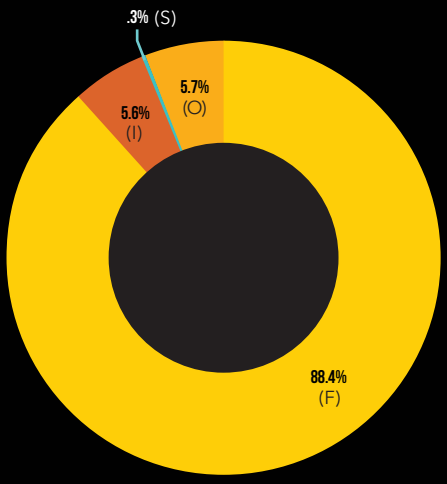
Externally funded sponsored research with a total project value of $10,000 or more.

TITLE	NAME	SPONSOR	TOTAL PROJECT VALUE	PERIOD	
Continuous Process for Solvent-Targeted Recovery and Precipitation (STRAP) for Plastic Wastes using Green Solvents	PI: Ezra Bar-Ziv Co-PI: Shreyas Kolapkar	National Science Foundation	$549,954	April 1, 2023	March 31, 2026
Solvent Targeted Recovery and Precipitation (STRAP) for Plastic Removal from Municipal Solid Waste (MSW)	PI: Ezra Bar-Ziv Co-PI: Shreyas Kolapkar	Battelle Energy Alliance – Idaho National Lab	$399,314	Aug. 23, 2022	Sept. 30, 2024
Torrefaction of Fiber-Plastic Blend	PI: Ezra Bar-Ziv Co-PI: Shreyas Kolapkar	Convergen Energy LLC	$57,500	May 1, 2023	Dec. 31, 2023
Simulation Methods for Optimal Fixture Design and Prediction	PI: Jason Blough Co-PI: Jim De Clerck	Honeywell Federal Manufacturing & Technologies LLC	$178,175	Feb. 1, 2023	Aug. 31, 2023
Performance and Lifetime Characterization of a Low-Power Hall-Effect Thruster	PI: Jason Blough Co-PI: Lyon King	Orbion Space Technology Inc.	$299,359	Oct. 27, 2022	Aug. 31, 2023
Development of a Methodology for Low-Frequency Sound Measurement for Field Test	PI: Jason Blough	Paul S. Veneklasen Research Foundation	$57,255	Sep. 25, 2022	Aug. 15, 2023
Integrated Control of Vehicle Speeds and Traffic Signals for Reducing Congestion and Energy Use Project Support	PI: Bo Chen	Oak Ridge National Laboratory	$90,623	Aug. 15, 2022	May 31, 2023
Electrification and climate resilience in the rural north: challenges and opportunities	PI: Ana Dyreson	Alfred P. Sloan Foundation	$723,929	Dec. 1, 2022	Nov. 30, 2025
Incorporating Climate Impacts into Electricity System Planning Models: Review and Case Study	PI: Ana Dyreson	Arizona State University	$107,985	July 1, 2022	Aug. 31, 2023
Collaborative Research: NNA Incubator: Sustainable Transitions through Arctic Redevelopment (STAR)	Co-PI: Ana Dyreson	National Science Foundation – Navigating the New Arctic (NNA) Program	$79,998	Oct. 1, 2022	Sept. 30, 2024
Prediction and Tuning of Spin Selectivity Properties of Chiral Nanomaterials via an integrated Machine Learning - First Principles Approach	PI: Susanta Ghosh	University of California, Los Angeles (UCLA)	$321,941	Sept. 1, 2022	Aug. 31, 2025

TITLE	NAME	SPONSOR	TOTAL PROJECT VALUE	PERIOD	
Hydraulic Noise Suppression Through HQ Tube	PI: Sriram Malladi	Caterpillar Inc.	$80,000	Dec. 14, 2022	Aug. 31, 2023
CAREER: Collective Hydrodynamics of Robotic Swimmers and Surfers at High Reynolds Numbers	PI: Hassan Masoud	National Science Foundation	$656,492	Dec. 1, 2022	Nov. 30, 2027
Limited Sharing	PI: Scott Miers	Limited Sharing	$86,382	March 31, 2023	Sept. 30, 2023
Gen2 Mini-PEMS Prototype Development	PI: Scott Miers	Michigan State University	$40,000	Oct. 1, 2022	Sept. 30, 2023
Impact of Fuel Additives on Stochastic Pre-Ignition	Co-PI: Jeffrey Naber	Center for Quality Assurance	$326,243	July 1, 2022	Dec. 31, 2023
Risk averse vehicle energy – thermal signature management and control to enable silent mobility/watch. Continuation	PI: Jeffrey Naber	University of Michigan (Department of Defense)	$112,680	Jan. 1, 2022	Dec. 31, 2023
Test Bed Creation for Testing of Hydrogen Fuel Injectors for Heavy Duty Vehicle Applications	Co-PI: Jeffrey Naber	Cummins Inc.	$40,705	Dec. 12, 2022	Sept. 22, 2023
Automatic Shut-Off Study on Vehicles Equipped with Keyless Start	PI: Jeffrey Naber	American Center for Mobility	$268,870	Sept. 30, 2022	Aug. 31, 2023
Reduced Cost and Complexity for Off-Highway Aftertreatment	PI: Jeffrey Naber Co-PIs: Darrell Robinette, Wayne Weaver	Battelle Memorial Institute (for Pacific Northwest Lab)	$870,320	Jan. 26, 2021	Dec. 31, 2023
Limited Sharing	PI: Jeffrey Naber Co-PIs: John Johnson, Gordon G. Parker	Limited Sharing	$1,720,127	April 1, 2022	March 31, 2024
Collaborative Research: ISS: Revealing Interfacial Stability, Thermal Transport and Transient Effects in Film Evaporation in Microgravity	PI: Aneet Narendranath Co-PI: Jeffrey Allen	National Science Foundation	$83,712	Oct. 1, 2022	Sept. 30, 2026

TITLE	NAME	SPONSOR	TOTAL PROJECT VALUE	PERIOD	
Development of a Robotic Testbed for Evaluation of High-Definition Maps for Autonomous Vehicles	PI: Vinh Nguyen	National Institute of Standards and Technology	$169,846	Sep. 1, 2022	Dec. 31, 2023
PREP Gaithersburg: Establishment of a NIST Gaithersburg PREP Program at Michigan Technological University	PI: Greg Odegard Co-PIs: Vinh Nguyen, Jeffrey Allen, Wayne Weaver	National Institute of Standards and Technology	$5,430,322	April 1, 2023	March 31, 2028
Institute for Ultra-Strong Composites by Computational Design (US-COMP)	PI: Greg Odegard Co-PI: Trisha Sain	National Aeronautical and Space Administration	$2,000,134	Aug. 1, 2022	Aug. 31, 2023
Ship Vibration Mitigation for Additive Manufacturing Equipment, Phase 2	PI: Gordon Parker Co-PI: Jason Blough	Advanced Technology & Research Inc.	$155,000	Sept. 30, 2022	Dec. 23, 2022
Range Extender Engine Test and Combustion Development	PI: Youngchul Ra Co-PI: Jeffrey Naber	Hyundai America Technical Center Inc.	$240,000	July 21, 2021	Dec. 31, 2023
Degradation-induced Performance Loss in Composites: Modeling damage accumulation through Concurrent Environmental and Mechanical Loads	PI: Trisha Sain	Karax LLC	$30,000	Aug. 1, 2022	Aug. 31, 2023
A Multiscale Multiphysics Computational Modeling and Experimental Study for Thermo-Oxidation in Polymers	PI: Trisha Sain	Department of Defense – Air Force Office of Scientific Research	$147,636	Aug. 24, 2022	Sept. 30, 2024
Limited Sharing	PI: Paulus van Susante	Limited Sharing	$59,847	July 25, 2022	Aug. 25, 2023
Percussive Hot Cone Penetrometer (PHCP) and Ground Penetrating Radar (GPR) for Geotechnical and Volatiles Mapping	PI: Paulus van Susante Co-PI: Jeffrey Allen	NASA SMD	$991,071	July 29, 2022	May 9, 2024
NASA 2023 Lunabotics Competition	PI: Paulus van Susante	University of Michigan – Michigan Space Grant Consortium	$10,000	May 1, 2023	April 30, 2024
Power Electronics and Advanced Modeling and Control for Energy Systems	PI: Wayne Weaver Co-PI: Shangyan Zou	Sandia National Laboratories	$105,000	Feb. 27, 2023	Feb. 23, 2024
Meta-Stability of Pulsed Load Microgrids	PI: Wayne Weaver Co-PI: Shangyan Zou	Sandia National Laboratories	$96,000	Dec. 1, 2022	Dec. 31, 2023

JULY 2022-JUNE 2023
SPONSORED AWARD TOTAL PROJECT VALUE BY SOURCE



Funding Source Total Project Value ($)

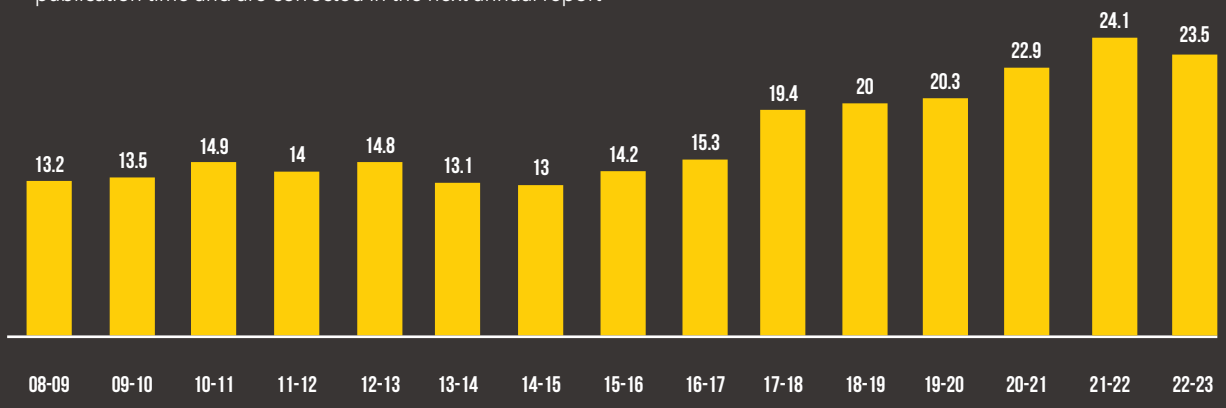
- Federal (F).....$13,227,263
- Industry (I) $857,691
- State of Michigan (S) $40,000
- Other (O) $831,914

Externally funded grants and contracts awarded July 1, 2022 to June 30, 2023 with total project value ≥ $10,000.

Nearly all (88.4 percent) of the total project value for external sponsored research awarded to MTU's mechanical engineering department in FY23 came from federal sources.

2008-2023
RESEARCH EXPENDITURES

Reported by the National Science Foundation (NSF) in millions. Research expenditures are an estimate at publication time and are corrected in the next annual report



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ME-EM

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CONNECT WITH US

Michigan Tech's Planetary Surface Technology Development Lab (PSTDL) is shooting for the moon—and beyond. Founded in 2019, the PSTDL is dedicated to prototyping, building, testing, and increasing the technology readiness level of tech being developed for lunar and Mars missions. Working with NASA on projects from rovers designed to research and navigate permanently shadowed regions on the moon, to next-generation infrastructure to deliver power from a power plant to a water extraction plant inside a crater, MTUengineering researchers and students work to make science fiction into reality.

mtu.edu/magazine/moon-beyond

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