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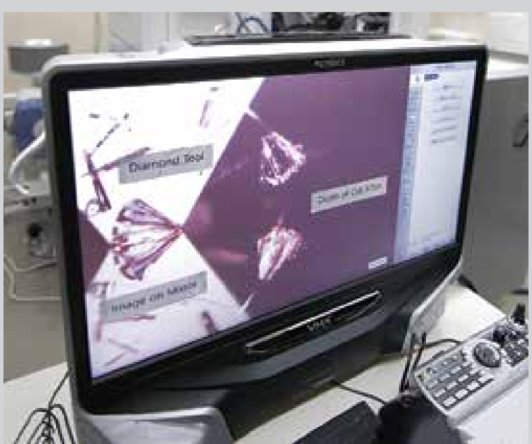
MECHANICAL ENGINEERING

UNIVERSITY OF WISCONSIN-MADISON

ADVANCED 'NANO-CUTTER' TO BOOST EMERGING MATERIALS RESEARCH



Jaal Ghandhi

GREETINGS!

The leaves have fallen off the trees and winter is settling into Madison, which gives me a chance to look back over the past year in the Department of Mechanical Engineering. It has been a year of significant progress on many fronts. Let's start with the faculty. The department now includes 11 assistant professors (out of a total of 31 faculty). This surge in hiring has been necessitated by a variety of retirements—our total faculty count has remained nearly constant—and the continued strong enrollment of undergrads in our department. We have taken a strategic approach to hiring. Last year we added three new faculty in the biomechanics area. This year, we have welcomed Wenxiao Pan, Benjamin Perherstorfer and Shiva Rudraraju to our ranks *(see profiles on pages 4-5)*. All three work in the area we refer to as computational engineering, and add an array of new expertise that complements the existing talents of the faculty. We anticipate great things to nucleate from these new colleagues.

Our undergraduate students continue to excel in national and international competitions. This year our students have been successful in the SpaceX Hyperloop competition, which we featured in our last newsletter; Formula SAE, placing 6th out of 115 entries; SAE Clean Snowmobile, winning the internal combustion class competition; Baja SAE, placing 4th out of 94 teams at the California competition; and many other events. This is a testament to the quality and dedication of our students and their faculty advisors, and the support we receive from alumni like you.

This year we have undertaken a concerted effort to increase recruitment and improve the retention of women in the department through the establishment of the Women in Mechanical Engineering (WME) program. The WME program pairs incoming freshmen with a successful junior or senior student and offers a variety of drop-in social events for the program members. Participation in the program is accompanied by a scholarship, and two alumni have stepped up with leading gifts to establish an endowed fund to support this activity.

This year has seen two major changes to our curriculum. The capstone senior design course that you will remember as ME 349 has been offered as a two-semester sequence for several years, but now incoming freshmen will be required to take the two-semester course. This change has been accompanied by a concerted effort to bring in industrially sponsored projects. This effort has been spearhead by lecturer Mike Cheadle. (If you or your company are interested in sponsoring a project, please feel free to contact either Mike, mcheadle@wisc.edu, or me). The second major curricular change, which has been led by Professor Greg Nellis, is the development of a required freshman-level introduction to engineering course in the department. (A similar course had previously existed at the college level). The course introduces engineering concepts through a hands-on project, and it highlights for the students where in the curriculum they will learn the required tools to fully address the types of problems they are encountering. These two activities, which involved considerable internal deliberation, represent the most significant changes that have been implemented since I have been part of the faculty and the initial feedback from the students has been overwhelmingly positive.

There is not enough space here to tell you about all of the accomplishments of the faculty, so I won't endeavor to give even an incomplete list. Best wishes to all for a productive 2017.

ON, WISCONSIN!

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Longtime engineering dean passes away

As dean of the UW-Madison College of Engineering, Paul Peercy constantly sought ways to help students succeed in engineering. In ongoing efforts to educate "global" engineers, he focused on diverse and interdisciplinary experiences, innovations in teaching engineering, and on hands-on work that connected the technical aspects of engineering students' education with real challenges facing society. "Engineering is where science meets society," he said in a 2012 interview, referring to myriad global challenges, including energy needs and pollution. "These are problems that can't be solved without engineers and can't be solved by engineers alone."

Peercy, who served as dean from 1999 until retiring in 2013, died Oct. 20, 2016, after a lengthy illness.

Read more and learn how you can make a gift in Peercy's memory that helps carry on his commitment to undergraduate education here: **go.wisc.edu/peercy-passes-away**

ADVANCED 'NANO-CUTTER' TO BOOST EMERGING MATERIALS RESEARCH

The College of Engineering is the new home of a unique machine that is capable of 3D milling precise to one nanometer. The machine, called the ROBONANO α-0iB, is the first of its kind in North America, and it brings extremely advanced technological capabilities that could represent the future of advanced manufacturing.

The ROBONANO, which is on a multi-year loan from the Japanese robotics manufacturer FANUC, arrived on Sept. 1, 2016, and is housed in the laboratory of Assistant Professor Sangkee Min, who is also a faculty member in the Grainger Institute for Engineering. Officials from FANUC traveled from Japan for a ribbon-cutting ceremony and open house for the ROBONANO, held Sept. 11, 2016. The ROBONANO's extremely precise capabilities offer Min and colleagues exciting new research opportunities, which he hopes will open up improved and novel approaches to the manufacturing of everything from semiconductors to mobile devices to scientific instruments.

The ROBONANO's superiority over previous generations of similar machines is obvious: Its ability to cut at the nanoscale is two orders of magnitude more precise than most machines used in advanced manufacturing today.

The ROBONANO is a 5-axis machine that uses non-contact air bearings, which gives it nearly limitless configurations for cutting, scribing and milling materials. Where it's truly exceptional, however, is in its nano precision. Many materials have different properties at the nanoscale, meaning the ROBONANO can potentially handle emerging and existing materials in new and useful ways.

Min will use the machine's unique capabilities to explore its suitability for manufacturing emerging materials, as well as currently available materials like synthetic sapphire, which is a promising shatter-proof alternative to glass for screens on devices such as tablets and smartphones. Synthetic sapphire—which is made from heating aluminum oxide to extremely high temperatures—currently is difficult to manufacture at large scales because it is very brittle and difficult to handle. However, Min has already conducted initial research on synthetic sapphire with the ROBONANO machine in Japan and discovered that the material sometimes behaves ductile when handled at the extremely tiny nano level.

Yoshiharu Inaba of FANUC Corporation does the ribbon-cutting at the college's open house for the ROBONANO.

It's primarily these differences in the physical properties of materials at the nanoscale that Min wants to explore, both in emerging materials and in materials like sapphire that require alternative handling methods to become truly manufacturable. Min also hopes to explore how the machine can help open up new possibilities for manufacturing design. Most designers are constrained by manufacturing limitations that can choke creativity and slow innovation. Min points to smartphone design as a prime example of this "design for manufacturing" paradigm leading to stale product lines.

"The design of the Apple iPhone has not changed very much since from the first one to the latest iPhone that was just announced," Min says. "It's the same for a lot of products. Vehicles are the same. A Ford looks like a Ford."

That's because manufacturers have long-term investments in supply chains that are difficult and costly to switch on a dime. The capital risk for changing a manufacturing process is often too high. Min says he hopes his research with the ROBONANO will identify ways to speed up the process and becomes one of the enabling technologies for a new manufacturing paradigm—what Min calls "manufacturing for design."

"I want to be able to ask the manufacturer, 'what is your perfect design?' And be able to provide that," Min says.

The ROBONANO has existed for more than 10 years in Japan, where the semiconductor industry is already using it to improve its products. Min says that the semiconductor industry is one among many industries that can benefit from the ROBONANO's capabilities. He's also been approached by the toymaker Lego and other well-known brands to help improve their products. "The opportunities are almost limitless for improving products and manufacturing processes with this machine," Min says.

WENXIAO PAN

Bridging varying scales with new applications

Wenxiao Pan works at the intersection of mechanical engineering and mathematics. Pan, who joined the Department of Mechanical Engineering in fall 2016 as an assistant professor, conducts research in multiscale modeling of fluids; she develops numerical methods with high-performance computing and applies them to complex fluids and soft materials.

Pan pursued her undergraduate degree at Peking University, in China, studying mechanical engineering. She knew early on that she preferred modeling and computation over experimentation, which led her to study applied mathematics at Brown University, where she received her PhD in 2010.

After graduating, Pan was a postdoctoral research assistant at the Pacific Northwest National Laboratory, a U.S. Department of Energy (DOE) government research lab in Richland, Washington. She continued on as a scientist at the laboratory for five years, conducting research in multiscale modeling and further implementation.

Working at a national lab gave her the opportunity to refine her current focus. "This experience allowed me to work on real-world problems and with real materials," Pan says. "I was exposed to a lot of relevant projects, which helped me gain clarity about what I wanted to do in the future."

While studying for her PhD, Pan knew she wanted to develop numerical methods, but for what, she wasn't exactly sure. It wasn't until she worked at the lab that she was exposed to different big problems that exist in applied mathematics and engineering. The national lab also provided a highly collaborative environment. "All the projects we worked on were big projects, so a lot of people were working together," she says. "I like that environment—it provides a good learning experience."

Her current research focuses on modeling at the mesoscopic scale, which involves transport phenomena in fluids and soft materials of intermediate sizes ranging from the molecular scale to the continuum scale. By linking different scales, researchers like Pan can achieve continuity in predicting how to design devices and materials in both "bottom-up" and "top-down" fashion.

In part, her work is bioinspired, and requires considering how biological systems interact and self-organize in nature to perform a specific function. By understanding how these reactions occur, she can better understand how to manipulate other materials to do the same.

Pan has maintained connections with the Pacific Northwest Lab and currently is leading one aspect of a five-year interdisciplinary project that involves two national labs and six universities. The Applied Mathematics Program within the U.S. DOE Office of Advanced Scientific Computing Research awarded the project, called the Collaboratory on Mathematics for Mesoscopic Modeling of Materials (CM4). "My task is to develop an efficient mathematical approach, as well as a scalable computational tool," she says.

She plans to carry on her research for the years to come at UW-Madison, working with a variety of applications. "I still need to keep developing my numerical methods, making them more rigorous, accurate and efficient," Pan says. "But I also want to explore more in application areas like microfluidics, directed assembly, additive manufacturing in solvents, energy materials and material processing."

Pan foresees collaboration across the UW-Madison campus, but particularly within the mechanical engineering department, which hosts a wide variety of research in simulation that is complementary to her work. She also looks forward to collaborating with colleagues in chemical engineering and materials science and engineering, as well as the mathematics department.

"I like the big university in that sense—there's a lot going on," she says. "Because my research is multidisciplinary, I do need to collaborate with specialists and experts in different areas, and a big university like UW-Madison offers those opportunities. Because the departments are so large and there's a lot of faculty doing different research, it's not difficult to find people to collaborate with."

Pan is teaching ME363: *Fluid Dynamics*, and looks forward to continuing her interactions with students and advancing her research.

How do scientists and engineers solve numerical problems that would require years upon years to solve on today's fastest supercomputers? They don't. Instead, with the assistance of mathematics, scientists and engineers can rely on approximations that provide answers that are sufficiently accurate for many applications and that can be computed in seconds on laptop computers.

Reducing the complexity of numerical simulations with mathematical tools is what keeps Benjamin Peherstorfer busy at his desk all day. Peherstorfer, hired through the college's Grainger Institute for Engineering, is a recent addition to the ME faculty. Peherstorfer takes complex computer models from engineers and scientists, develops mathematical tools to reduce them to only the very essential components, and performs the mathematical analysis to ensure the error introduced by this approximation is within an acceptable tolerance.

While approximations may seem not ideal, Peherstorfer says the computer models in engineering and science have become so complex that simply buying a larger computer is not an option. "Using reduced models is really not about making it fast, but about making it possible at all," Peherstorfer says.

So, what are these incredibly complex problems Peherstorfer is interested in?

One is related to numerical simulations of rocket engines. Peherstorfer uses his computer modeling methods to account for the uncertainty inherent in these problems: "In virtually any engineering system, uncertainties are introduced because of incomplete data, measurement errors, or tiny variations in the manufacturing process," Peherstorfer explains. "So how do these small variations affect the system? To estimate the effects, we perform millions of numerical simulations to make statistical statements on how likely it is for the rocket engine to fail, for example. Reduced models are essential to make these computations tractable."

To complicate Peherstorfer's research, he works in the context of inverse problems, as opposed to forward problems. "In forward problems, you have the inputs and you feed

BENJAMIN PEHERSTORFER

Developing mathematical tools to make tractable large-scale numerical simulations in engineering

them into your numerical simulation and to get your output. In inverse problems, you have the output and you would like to know what inputs gave rise to that output," Peherstorfer says.

A common real-world example of an inverse problem is X-ray computed tomography, where an object is imagined based on how it scatters incoming X-rays. A computationally very demanding inverse problem is imaging subsurface Earth based on seismic waves. Roughly speaking, inverse problems require more computing power and are more difficult to answer than forward problems, Peherstorfer says. "When you now think that you additionally want to quantify uncertainties in inverse problems, then you can again see the need for developing cheap and certified reduced models," he says.

He has long been interested in computational problems in science and engineering and harnessing the power of computers to help find solutions—or at least approximations—to them. He received his bachelor's, master's and PhD in computer science at the Technical University of Munich in Germany. There, he was a member of the scientific computing group and worked on machine learning to detect patterns in data streams in real-time.

Peherstorfer comes to UW-Madison from a postdoctoral position at Massachusetts Institute of Technology in its aerospace computational design laboratory. While at UW-Madison, he plans to work on multi-fidelity modeling to combine multiple computational models for uncertainty quantification in inverse problems. In addition, he's establishing research collaborations that go beyond the department and college.

"I am absolutely excited about the incredible collaboration opportunities at UW-Madison," Peherstorfer says. "UW-Madison provides a very collaborative environment, which is a great opportunity for me and my interdisciplinary research that cuts across math, computer science and engineering."

SHIVA RUDRARAJU

A computational physicist who studies mechanics and morphology evolution in materials

In January 2017, Shiva Rudraraju will join the department as an assistant professor. Also an affiliate of the college's Grainger Institute for Engineering, he comes from the University of Michigan, where he's been a graduate student, postdoctoral fellow and research scientist for 10 years.

Rudraraju is a computational physicist. His research focuses on two broad areas: using computational physics to study the response and evolution of materials, and developing/leveraging high-performance computing algorithms for solving problems in materials physics. "I'm really excited about what the College of Engineering and the Grainger Institute for Engineering have to offer in terms of their collaborative environment," says Rudraraju.

He received his undergraduate degree in India. At Michigan, he studied failure in composite materials, especially in the context of aerospace structures. That research was in collaboration with NASA and Boeing. Following his PhD, Rudraraju was heavily inspired by the work done at the computational physics group in Michigan. This helped him look at broader aspects of computational physics, primarily driven by high-performance computing, to understand multi-scale processes in biological, structural and functional materials. In addition to collaborating with other computational physicists at Michigan and through the Department of Energy's PRISMS center, Rudraraju collaborates with researchers at the University of Oxford on modeling growth and morphology evolution in biology.

Continuing that collaboration is one of Rudraraju's three main goals when he arrives at UW-Madison in January. "Going forward, a significant part of my research focus will continue to be in biology, especially looking at multi-physics processes and growth phenomena in biology," Rudraraju says. "I'll continue my exciting collaborations with the computational physics group at Michigan and with the University of Oxford, where we are looking into the shape evolution in sea shells. This work has implications for understanding evolutionary dynamics."

Rudraraju's second goal is to continue his work in materials science, especially on multi-scale modeling which can potentially lead to the discovery of new structural and functional materials. He'll especially focus on modeling the mechano-chemical processes in metallic alloys and battery materials.

Rudraraju is also very excited to leverage his strength in high-performance computing for developing new collaborations across the College of Engineering campus. He says that the Grainger Institute for Engineering's emphasis on transdisciplinary collaboration was a factor in his decision to come to Wisconsin from Michigan. "The institute has this very active role in terms of collaborating in the discovery of materials and in advanced manufacturing," Rudraraju says. "With my background, I want to look for active collaborations across the institute and beyond."

In addition to his research plans, Rudraraju plans to teach courses on mechanics, numerical methods and applications of high-performance computing, reflecting his evolving interests from his undergraduate years in India to his present research on high-performance computing driven computational physics. "When I was younger, my interest was primarily in physics," Rudraraju says. "I knew I wanted to work on physics, especially mechanics and its applications; hence I chose to study and later continue research in mechanical engineering."

After his undergraduate years, Rudraraju pursued internships at the Helmholtz-Zentrum Dresden-Rossendorf and Technische Universitat Freiberg, both in Germany, where he was introduced to the computational aspects of mechanics. "It was a very organic route starting from my interest in physics, extending to computational mechanics and computational physics, and then to applications in materials and biology," he says. "So I'm still primarily driven by that curiosity in physics."

ALUM FRANK SANDERS RECEIVES COLLEGE OF ENGINEERING AWARD DURING THE ENGINEERS' DAY CELEBRATION NOV. 11, 2016

*Read even more about our recipients: **www.engr.wisc.edu/eday***

DISTINGUISHED ACHIEVEMENT AWARD

FRANK SANDERS

Vice President, Technology & Manufacturing Group;
Director, Global Systems Supply Chain
and Technology Enabling, Intel Corp.

MSMSE '92

(BSME '89, University of Illinois; MBA '07 Northwestern University)

Why did you choose engineering as your major?

My dad and my uncles were always car fanatics; as a matter of fact, they were amateur drag racers and they built car engines and cars to race—and I remember asking my dad who designs engines. And he said engineers do. So at a very early age, I knew that I wanted to be an engineer. ... I considered electrical engineering, but I always liked the mechanical world—the things you can really touch and feel and kind of get your arms around. Over the course of the years, I got really interested in control systems, because in my mind that was really where the electrical/digital world and the mechanical world interacted. And so when you look at what I studied at Wisconsin and the kind of things that have interested me since that time, it's definitely been those kinds of things that combine those two in an evolving world.

Who was your favorite engineering professor?

Professor Robert Lorenz. I was really passionate about controls, and Bob was an expert in this space, not just from an academic standpoint, but also when it came to real-world applications. I remember Bob as a really smart guy who had that special passion and you knew that he absolutely loved what he did—and that was really inspiring.

Of what professional accomplishment are you most proud?

Probably the broad proliferation in Wi-Fi that Intel enabled across the industry and the role I played in driving critical elements of the supply chain in support; we launched a product platform called Centrino after the turn of the century. Wi-Fi technology was available, but not broadly proliferated, not until we launched it on our Centrino mobile wireless platform. In our business, we typically didn't bundle connectivity solutions without our microprocessor products. In this case, we said it's going to be sold as a platform ... I was responsible for a lot of the key capabilities, the elements in support of that supply chain. And it was hard. The project essentially went from zero to 100 in a matter of months, and it wasn't about going out and securing stuff that was readily available in that industry; we had to work a lot, strategically, with ecosystem players, to develop new technologies to invest millions of dollars in capacity expansions, and we had to do it within time frames that were much tighter than what was typical in the industry. And so when I look back and think about how we hurdled all of the obstacles, it was probably one of the most successful product platform launches in the history of the company—and also when you think about the implications to the world, it's what made Wi-Fi become the de facto technology across the industry for mobile computing. I take a lot of pride in that.

What are your hobbies/interests?

My Christian faith is important to me and I continue to try to balance my spiritual life with other aspects of my life. I really enjoy spending time with my family. My wife Prudence and my kids Brooke, 10, and Grant, 4, are a joy to be around and they keep me grounded. My parents, in-laws and the majority of the rest of my family are in Illinois. I don't get to see them as much as I like but I cherish every moment I get with them as well. I'm also a big fan of college athletics ... I went to two other Big Ten schools, as well: Illinois as an undergraduate; Northwestern for a master's in business, and so my loyalty is with the Big Ten.

ELEVATING THE PROFILE OF U.S. MANUFACTURING

Although Associate Professor **Frank Pfefferkorn** recently spent time working in Washington, D.C., he notes that he wasn't on a sabbatical. "I was on loan to the federal government by the state of Wisconsin for 12 months," he says.

From September 2015 through August 2016, he served in the Advanced Manufacturing National Program Office (AMNPO), where Pfefferkorn helped coordinate manufacturing policy for the United States.

The AMNPO is an interagency office staffed by representatives from federal agencies and by fellows from U.S. industry and academia. "The office's charge is essentially to help coordinate all of the manufacturing activities across the federal government. That's a very tall order," he says.

The AMNPO is best known for coordinating the National Network for Manufacturing Innovation Institutes. The network's new public-facing name is Manufacturing USA, which resulted from an identity and branding campaign that Pfefferkorn worked on. Manufacturing USA was created in order to help ensure that U.S. inventions are also manufactured in the United States. "This national network—Manufacturing USA—is intended to help these institutes communicate with each other and find mutual interests. It also helps them reach the public and companies," he says. "Each institute is its own entity, and they each have a goal of creating a hub, of building enough critical mass of advanced manufacturing expertise in a region, that will sustain itself and create new jobs, new processes and new products."

During his 12-month assignment, Pfefferkorn acted as a liaison from the AMNPO to other federal agencies, among other activities. Working at AMNPO gave Pfefferkorn a better sense of the pressing needs faced by industry in the manufacturing area, and that has prompted him to pursue more applied research projects that come directly from industry. "I'm now actively working on doing more projects with companies," he says. "I'm continuing to work on fundamental research, but I'm adding more applied research as well to help transfer that knowledge to industry."

CRASH COURSE:

ALUMNA AIMS TO MAXIMIZE VEHICLE SAFETY

Becky Mueller still remembers the first time she observed a car crash simulation—the sheer unpredictability of a vehicle speeding down a runway, headed toward an unforgiving cement wall.

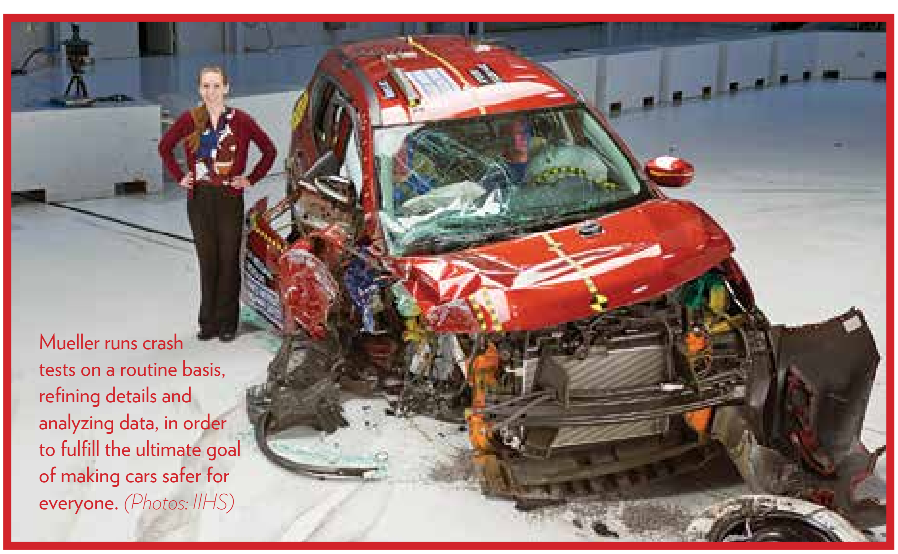
"It was an adrenaline rush, to see all of that work be over in a tenth of a second, but also to see the magnitude of forces and motion that define what a crash really is," says Mueller (BS '07), who currently works as a senior research engineer and crash coordinator at the Insurance Institute for Highway Safety (IIHS). "There's so much happening, and you know you're going to be able to learn something about the car almost instantly."

Her first exposure to real-world crash reconstructions was through General Motors, where she worked as an intern in the company's vehicle safety group. These reconstructions are now a staple of her career—she runs crash tests on a routine basis, refining details and analyzing data, in order to fulfill the ultimate goal of making cars safer for everyone.

Modern cars are equipped with a vast amount of technology aimed at making them safer, both for the people who drive them, and nearby pedestrians and bicyclists. However, the standards for safety aren't always quite as clear as they should be. Mueller and her colleagues devise tests for auto manufacturers that ensure a baseline standard of safety for consumers. These tests result in ratings that essentially tell customers how safe a given model of car really is.

"There are people who write in to our website and talk about how they chose a vehicle with a good rating, and how that well-rated vehicle saved his or her life," says Mueller. "We have front airbags and side-airbags in cars because of a lot of the work we do here. So when I drive by an accident, see airbags deployed and the car's passengers safely outside of the vehicle, I know that person was able to walk away because of the work that we do. Without ever having met these people, I have improved their lives."

Mueller grew up with an affinity for cars, and upon discovering the existence of car crash ratings, she knew that she would be interested in a career path involving vehicle safety. By pursuing engineering, and mechanical engineering in particular, she would be able to apply her passion in a way that would make a positive impact. She graduated from UW-Madison with a bachelor's degree in mechanical engineering in 2007, after conducting undergraduate research under Professor Greg Nellis. While pursuing her degree, she also joined the UW Hybrid Vehicle Team, mentored by Glenn Bower, taking on leadership roles as mechanical group leader and later, team captain. She credits this experience for many of the "ah-ha!" moments that led her from the classroom to her summer internships with General Motors.



Mueller runs crash tests on a routine basis, refining details and analyzing data, in order to fulfill the ultimate goal of making cars safer for everyone. *(Photos: IIHS)*

"The Hybrid Vehicle Team was essential to my future success, and not just because I was working with cars, but because I was able to apply my skills to problems that haven't necessarily been solved," she says. "You have to know how to react to that, how to move forward, using your creativity and drive."

Mueller earned her master's degree in mechanical engineering from Purdue University in 2009, where she was involved in research on biomechanics. Through this research, she was able to better understand injury tolerances for the human body. After graduating, she worked at TRC Inc. of Ohio as a contractor to the National Highway Traffic Safety Administration, before joining IIHS in 2010.

Mueller is currently working on improving frontal-crash protections, specifically for passengers. This involves producing new tests that not only ensure structures that protect occupants in the driver's seat, but right front passengers as well. Because manufacturers compete over good scores on these tests, they are motivated to improve their safety standards. "Safety sells, and it's one of the top five things consumers look for," Mueller says. "It gives the manufacturers further incentive to improve their technology."

Students Zach Vargas *(left)* and Luke Steinbach look on as Roy Thorson plays the baritone horn using their device.

In people with muscular dystrophy, severe muscle weakness can greatly inhibit any form of movement. For Roy Thorson, a 14-year-old from Wausau, Wisconsin, the condition often prevents him from doing the thing he loves most: playing his baritone horn.

When he met Christopher Luzzio, an associate professor of neurology (and ME affilliate), Roy knew how to play the baritone, but was only able to blow through the mouthpiece while one of his parents pressed the keys. Luzzio decided there was no better way to face this problem than present it to mechanical engineering students in his course, ME 601: *Design for Rehabilitation*.

The project involves the use of small buttons to power a pneumatic system, which in turn actuates the keys on the baritone. The students,

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FOR YOUTH WITH MD, STUDENTS' SYSTEM REDUCES BARRIERS TO PLAYING BARITONE

Luke Steinbach and Zach Vargas, initially struggled to identify a way to connect the slight mobility of Roy's fingers to the instrument itself.

They drew on the expertise of Professor Emeritus Frank Fronczak who advised that they use a pneumatically powered system that makes use of an air compressor.

The students also designed and 3D printed a hand controller—specifically molded to the shape of Roy's hand—with buttons that would be both comfortable and highly convenient. When Roy clicks a certain button on this controller, which is shaped much like a computer mouse, the signal travels through a small hose and actuates the air compressor, which depresses the corresponding valve on the baritone. As a result, Roy can play his instrument independently.

Since devising the system, Steinbach and Vargas have worked with Luzzio on multiple iterations to make it highly efficient. This is not the first individual-based project on which Luzzio and his students—both past and present—have embarked. In previous classes,

his students designed a system that could flip the pages on a Nook for a person with muscular sclerosis with limited hand mobility. Another project—which has not yet reached completion—involves a device that allows artists with muscle weakness to paint using a joystick to control a brush's movement and stroke types.

"I think it's very exciting to identify someone, then build something specifically for them, to improve their quality of life," Luzzio says.

More often than not, these projects present themselves to Luzzio, whose medical practice centers around multiple sclerosis—and as a result, has many patients with both unique and common needs. He makes an effort to serve as many of these needs as possible using engineering solutions, but often, the more interesting and engaging projects are those that put students in contact with an individual, who serves as their client for the semester.

For design classes such as his, which are largely geared toward seniors and graduate students, Luzzio looks for hands-on projects that will allow students to build something, learn something about computer control, and offer multiple levels of interaction, both with him, the client, and each other. As is the case in the workplace, the students draw on any resources available to them and work with each other and their client to determine the best solution for their client's design challenge. And as they've learned, there's not always just one answer, but the outcome generally is rewarding both for students and client.

This project was possible thanks to support from donors Pat and Leroy Fischer, Rita and Jason Keys, and Stuart and Polly Brandes.