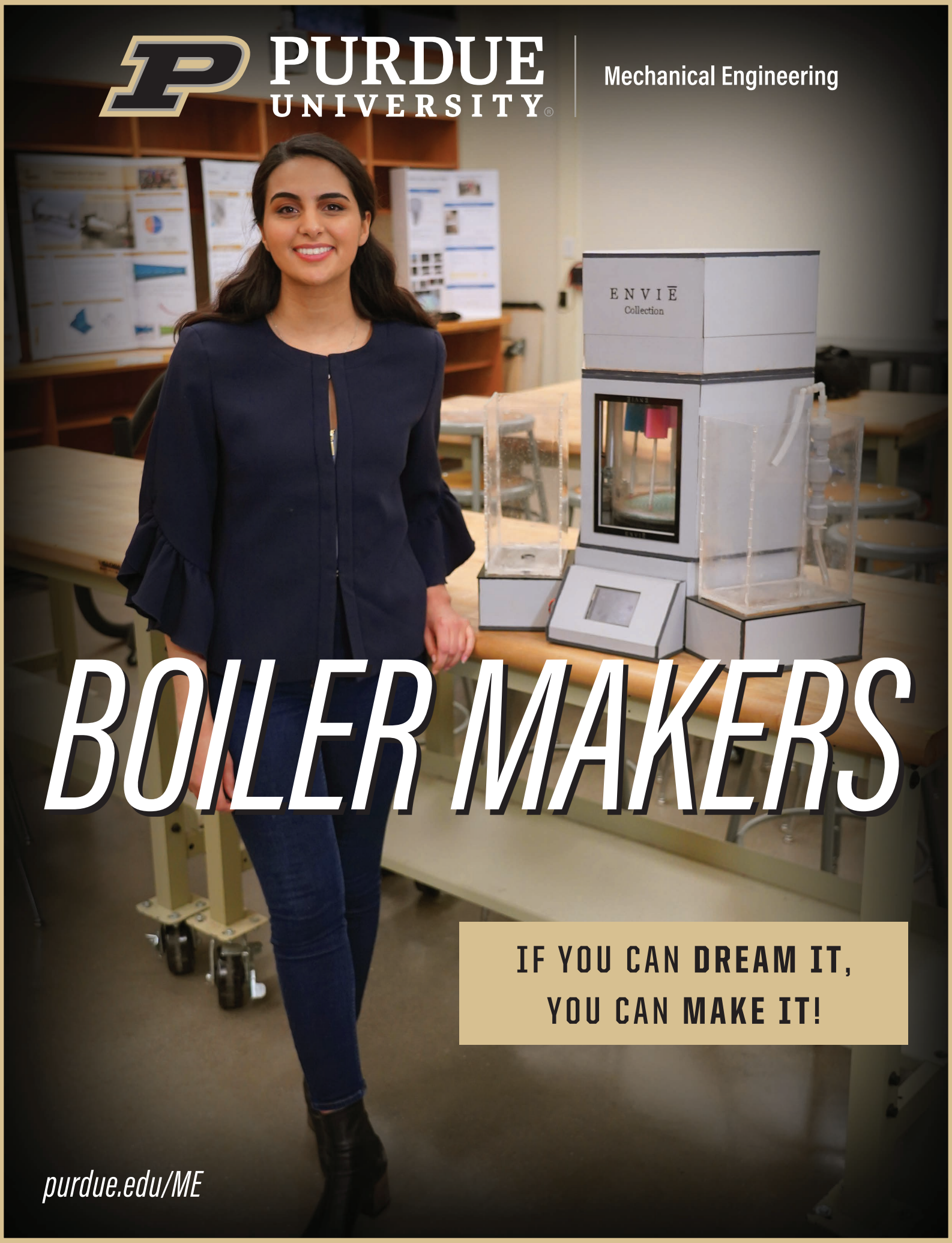

PURDUE
UNIVERSITY
Mechanical Engineering
ENVIĒ
Collection
BOILER MAKERS
IF YOU CAN DREAM IT,
YOU CAN MAKE IT!
purdue.edu/ME

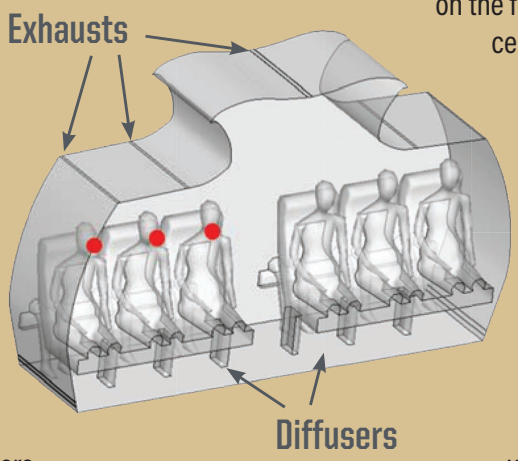
IS IT SAFE TO TRAVEL?

Let's ask Purdue ME's expert in the field

In February 2020, a cruise ship carrying COVID-infected passengers decided to quarantine at sea. According to Prof. **Qingyan (Yan) Chen**, that's the worst thing they could have done. "Cruise ships mix outside air with inside air to save energy," he said. "But their systems don't filter out particles smaller than 5,000 nanometers, and coronavirus is about 120 nanometers. The air conditioning system would be carrying the virus to every cabin."

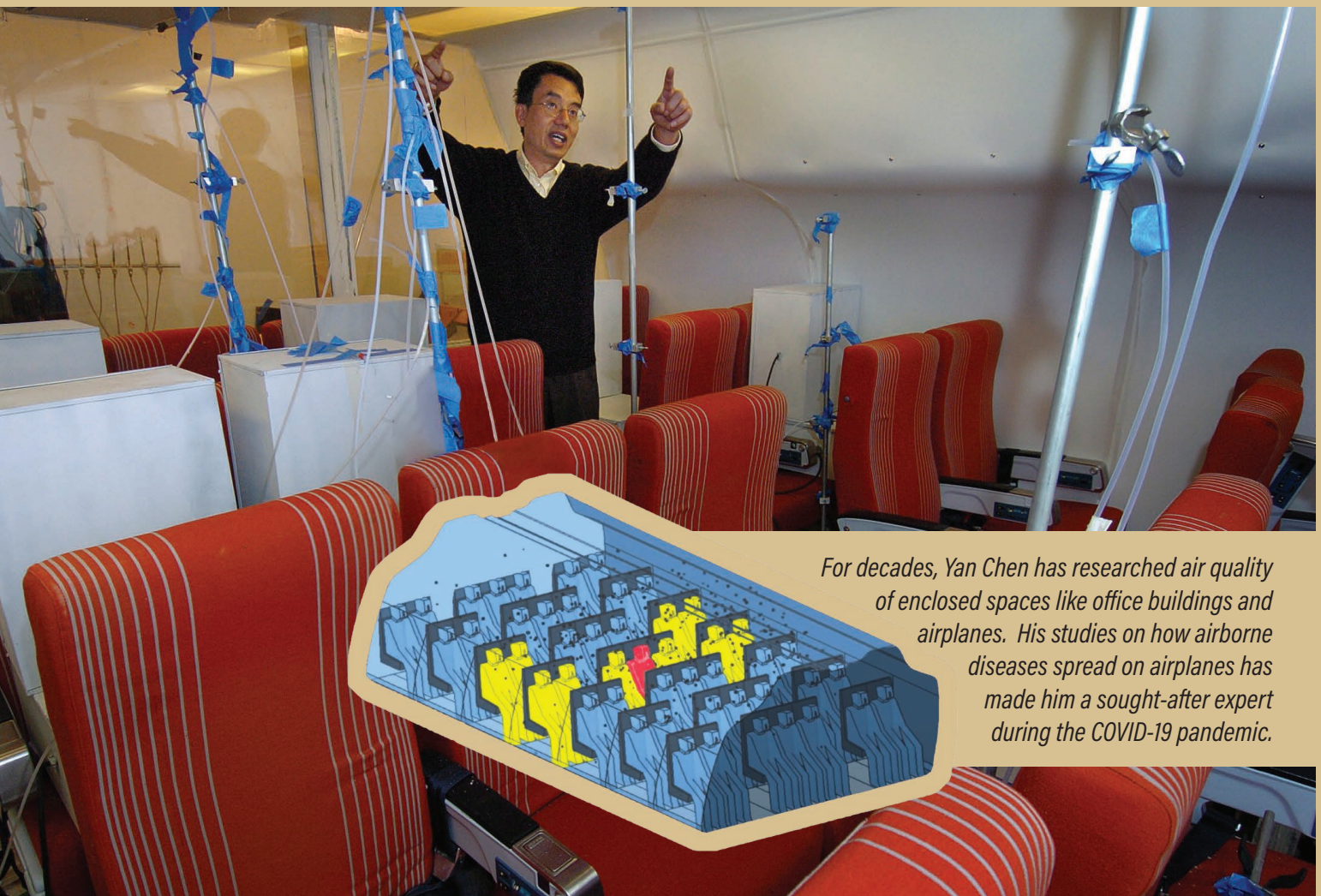
Chen studies airflow and ventilation, specifically of enclosed spaces like office buildings and airplanes. That made him the center of attention for news outlets during the COVID-19 pandemic, where his work was cited more than 1,000 times in just a few months. They all asked the same question: "Is it safe to travel?"

Unfortunately, the answer isn't clear. While airplanes use higher-quality air filters, droplets can still circulate based on airflow patterns through the cabin. Chen proved this in 2004 during the first SARS epidemic, when he built a full-sized mockup of a Boeing 767 at Purdue's Herrick Labs. He found that droplets simulating a sneeze from a middle-seat passenger spread a fair distance through the cabin, due to the airflow patterns of the plane's ventilation system.



His solution? Every passenger's seat should have a diffuser on the floor with a HEPA filter, and an exhaust in the ceiling. This creates an individual circulation pattern for each passenger, and reduces the chance that micro-droplets would escape any individual's "bubble."

While Chen continues his work, the best we can do to protect ourselves is to follow social-distancing guidelines, such as wearing masks in public spaces. "We can never totally eliminate risk," he said. "But whether there is a pandemic or not, we are always working to make these systems safer."



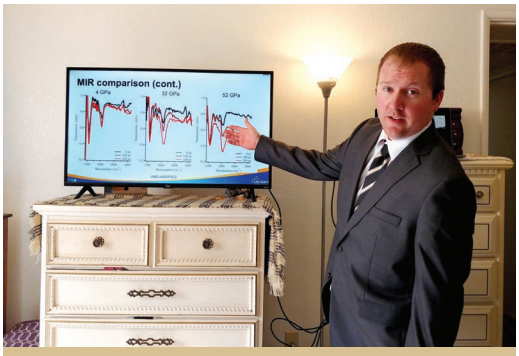
For decades, Yan Chen has researched air quality of enclosed spaces like office buildings and airplanes. His studies on how airborne diseases spread on airplanes has made him a sought-after expert during the COVID-19 pandemic.

PROBLEM SOLVERS

We always tell our students that engineering is all about solving problems. Well friends, the year 2020 has tested that ability to the limit! Because of the COVID-19 lockdown in March, our faculty had just one week to transition all of their classes to online delivery. This was a heroic effort on behalf of all involved, and while online experiences are not always ideal, it's a credit to everyone who has showed their flexibility. Everything had to be moved online: study groups, PhD defenses, and even commencement!

Nobody knows exactly what the future holds. But I can tell you this: nobody solves problems like Purdue Engineers. In this magazine, you'll read about amazing students, faculty, and alumni that have put their education to work in the real world, seeking out problems and creating innovative solutions.

Most importantly, I want you to know this: **we are still Purdue**. That hasn't changed, and it's never going to change. The things that make Purdue what it is, won't be changed by disease, or quarantine, or anything else. We are still Boilermakers, in the business of moving the world forward. Even if we have to do it through new methods, nothing's going to stop us.



PhD candidate Michael Powell successfully defended his thesis from his bedroom in New Mexico.

Eckhard Groll
William E. and Florence E. Perry Head and Reilly Professor of Mechanical Engineering

Rachel Goldman (BSME '20) celebrated commencement at home, while the Purdue ME faculty cheered via video.

PURDUE UNIVERSITY | Mechanical Engineering

585 Purdue Mall
West Lafayette, IN 47907
Phone: (765) 494-6900
Website: **purdue.edu/ME**

facebook.com/PurdueME
twitter.com/PurdueME
youtube.com/PurdueME
instagram.com/Purdue.ME
linkedin.com/company/PurdueME

This magazine was produced by Jared Pike, Communications Specialist, School of Mechanical Engineering: jaredpike@purdue.edu

THIS MAGAZINE IS
INTERACTIVE!

Watch videos of every story, and get bonus content at:
purdue.edu/ME/magazine

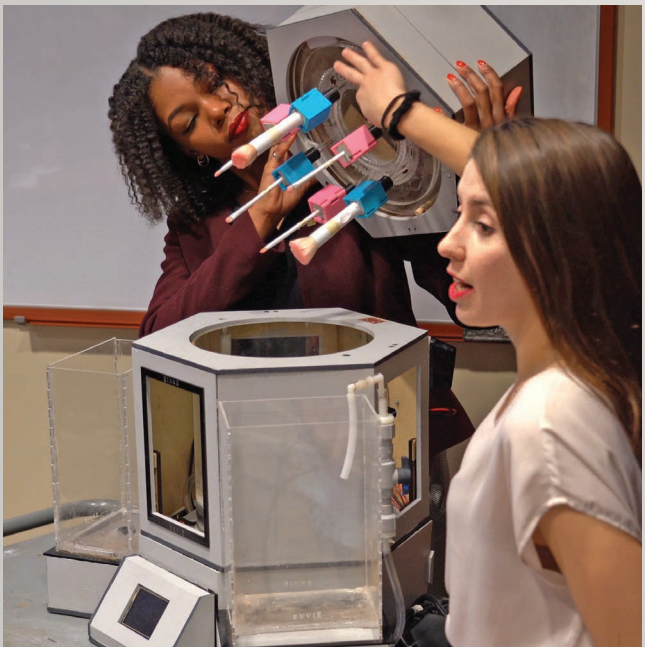
Cover photo: Graduating senior Dina Abdulaal shows off Envie, a machine that automatically cleans makeup brushes. She was part of a predominantly female team of students who built the prototype as part of their capstone senior design class.

HOW DO ENGINEERS CLEAN MAKEUP BRUSHES?

A predominantly female team of ME students developed Envie, an award-winning makeup brush cleaning device that automatically washes, rinses, and dries multiple makeup brushes in just seven minutes

"There's nothing else like it in the market," said **Dina Abdulaal**, a graduating senior who was part of the team that created the Envie prototype. "It's a high-end solution designed for professionals, like makeup artists and beauty salons. A full set of makeup brushes consists of 10 to 20 brushes, and most people wash them by hand over a sink, which is very time-consuming and puts a lot of strain on your wrists! Envie does it all for you, in a fraction of the time."

Envie is a hexagonal chamber, with a clean water tank on one side and a dirty water tank on the other. The lid contains holders for six makeup brushes. Once the brushes are loaded and the touchscreen controls activated, the main chamber fills with a small amount of water and cleaning solution. The brushes revolve through the water, as they independently rotate to maximize the cleaning motion. A second cycle rinses the brushes, and a third dries them – all without any user intervention. Tedious hours of work are now accomplished automatically in seven minutes; and instead of a manual process that takes up to 99 gallons of water, Envie uses just 0.25 gallons. "We're really proud of the result," said Dina. "It may be a prototype, but it's a high-quality product."



KNOW YOUR CUSTOMER

Senior Design (ME463) is the capstone class of Purdue's Mechanical Engineering curriculum. Students team up, and have one semester to create a prototype product, combining the knowledge they've gained over the past four years of classes. Since most engineering students are men, very few cosmetics-related projects have emerged from the senior design class.

To Dina, that presented an opportunity. "I first thought of this idea when I was cleaning my own makeup brushes," she said. "It takes hours, and the drying time is even longer. And apparently you're supposed to do this every two weeks!"

She presented the idea to her team of fellow seniors – Mina Mohsenian, Robbie Williams, Kevin Sanabria, Heya Kaakeh, and Emily Eifert – who decided to create a device to automate the process, aiming it at the professional market.

First, the team surveyed potential customers to determine their needs. "We did more than 100 surveys," said Dina, "and we also interviewed people at different beauty schools and salons. We really wanted to understand our customers. The most important things they requested were the ability to clean multiple brushes at a time; the washing and drying to happen all in one cycle; and the whole process to take less than an hour. We eventually accomplished all these criteria in just seven minutes!"

MAKE IT OR BREAK IT

For the design process, the team delegated the many requirements of the prototype. "We spent a lot of time drawing on whiteboards," said Dina. "We designed for each function, and then combined everything together. It was a very collaborative process."

They also worked together to construct the prototype. They 3D-printed the makeup brush holders, and laser-cut the planetary gears that spun the brushes. They laser-cut a

plywood exterior, and painted it gray so the machine could visually blend in with any salon setting. They built watertight acrylic tanks, as well as an acrylic tunnel to protect electronic components from water. They also had to program the electronics for the touchscreen controls. For the drying process, they purchased on off-the-shelf car heater, and built ductwork to channel the hot air into the washing chamber.

For Kevin Sanabria, the only male team member, it was an educational experience of a different kind. "Honestly at first, I had some fear," he remembers. "I could sense what some females go through when they're on a predominantly male team, fearing that their input might just be put on the sidelines or disregarded. But that wasn't the case. Everyone's input was highly regarded and encouraged strongly. If one of us wasn't speaking up at a meeting, we'd make it a point to hear from them and understand what their thoughts were. Even though I was new to the subject, I felt more than welcome to contribute my thoughts and pitch in."

Dina took particular pride in her role as procurement and project management. "I had never done procurement before," she said, "so it gave me a great opportunity to learn something new, and help keep us all on track!"

After a few frantic weeks of constructing the prototype, their first test did not go well. "One of our pumps burnt out, which was pretty scary, as we were coming up to the deadline," recalled Dina. "We were able to find another pump to fit to the machine. But eventually, it worked!"

AWARD WINNING

The final step in Senior Design class involves presenting the prototype to a panel of industry judges. For many students, this process can be just as intimidating as the design or construction phase. But the panel of judges were so impressed by the Envie team's presentation, they unanimously awarded the team 1st place among all senior design projects that year,

as part of the Malott Innovation Awards (a competition created by former Siemens CEO Thomas J. Malott to foster an innovation culture at Purdue). Malott remarked afterwards, "They gave the best presentation I have observed over all of the years that we have had this program. They defined the need, the size of the market (half of the world's population!) and the pricing that they felt they could get for the product. They could have used this presentation successfully with any set of investment bankers in the real world. Their ideas clearly could form the basis for a sound business."

For Dina, the award validated all the hard work she and her team put into Envie. "I feel like I got the chance to go through the full cycle of product development," she said. "It was very exciting, and it's definitely going to help me as I go into the working world."

Kevin agrees: "I hope I can see the day that Envie is used by professional salons. With an exceptional idea and an exceptional team, there are no limits to what you can achieve!"

Dina also wanted to encourage others to think outside the box when it comes to engineering. "Mechanical Engineering doesn't just have to be bolts and gears," she said. "You can also build a machine like this. You can do whatever you want with this degree. If you're thinking about it, I say go for it!"

I was a Purdue Engineering student...

THEY WEREN'T ABOUT TO MESS

Fifty years after graduating, Alan Kennedy (BSME '69) looks back on his career as a senior patent attorney at NASA, and how Purdue Engineering helped him get there

Alan Kennedy's years contain many twists, turns, and inspiring stories. It all started in Kokomo, Indiana, where Alan was born and raised. After high school, he got a job at the Chrysler factory in Kokomo, which die-cast parts for engines. But it wasn't quite what he expected. "I went in with my clean powder-blue overalls," he remembers. "And they gave me this nasty job, mopping up oil around a die-cast machine. I went home that night and looked at my brand-new pants, and they were ruined. And I cried! This wasn't me."

Alan decided that his love of the hard sciences would fit well with engineering, and Purdue was the closest school that offered it. "This was the summer of 1963," Alan remembers. "Martin Luther King had just led the March on Washington. People asked me, 'You want to be an engineer? We don't even know any black engineers!' But I still wanted to do it. I applied, I got in, and did pretty well my first semester."

But he only had enough money for one semester. "I was flat broke," he says. "My back was to the wall. Am I going to go back to Kokomo and be a janitor or a laborer?"

That's when Alan discovered Purdue Engineering's Cooperative Education Program. Founded in 1954 by Mechanical Engineering professor Frederick Morse, the co-op system allowed Purdue Engineering students to alternate semesters between taking classes, and working in industry – providing them with both an educational experience, and a paid full-time work position.

But in the decade since its founding, no black student had ever undertaken a co-op. That was about to change. "I put on my best sportcoat and pants," Alan recalls, "found the co-op office, and the guy was nice as can be. He told me, 'I want you to be the Jackie Robinson of the Purdue Engineering Co-Op Program!'"

They placed Alan with Haynes Stellite, a manufacturer of metal alloys based in his hometown of Kokomo. He worked for a semester, earned enough money to continue his studies in the classroom, and then returned to Stellite for another semester of work. For the hometown kid, it was a far different experience than mopping up oil at the die-cast plant down the road. "When I came into Chrysler, I was a black laborer," says Alan. "When I came into Stellite, I was a Purdue Engineering student. They weren't about to mess with me!"

Alan Kennedy (front row center) was part of Purdue's Kappa Alpha Psi fraternity in 1969.

WITH ME!

After graduating, Alan's contacts at Stellite led him to a design engineer job at GE's Appliance Park in Louisville, Kentucky. "One day, the company's patent attorneys came around to show us how to keep our lab notebooks," says Alan. After discovering the work of patent law, Alan became hooked. "They make good money. You can go to work in a suit and a tie. Hey, that's me! So like a laser beam, I became focused on getting a job in patent law."

Alan was transferred to GE's facility in Columbia, Maryland, and began attending night law school courses at the University of Maryland. "Let me tell you the difference between law school and engineering," says Alan. "In engineering, there is always a right answer. What you work on has to function correctly. Law school is different. The 'right' answer is whatever you are required to do on behalf of your client."

And patent law is a different entity beyond that. Patent lawyers specialize in working on behalf of inventors for the very specific and rigorous process of filing claims with the US Patent and Trademark Office. "To be a patent lawyer, you need a technical background – engineering, physics, chemistry – in addition to the law background," says Alan. "So it was perfect for me."

After finishing his law degree, Alan stayed in the Washington area, working as a patent attorney for Xerox and for the US Army. Then he discovered NASA. "Goddard Space Flight Center had an opening for a patent attorney, and I thought that would be a great place to work," Alan says. "I stayed there two years, and then got promoted to senior patent attorney at NASA Headquarters in Washington, DC."

As a senior patent attorney, Alan adopted a more administrative role, working with all of NASA's facilities across the country. "I was director of the infringement division," says Alan. "If somebody sued NASA or one of their contractors for infringement, I would coordinate discovery – the gathering of evidence – for the case. These were multi-million, and sometimes billion, dollar lawsuits. That's a pretty big deal, and these are some of the smartest people in the world."

Defending NASA's logo and trademark was an unenviable task. "NASA's name and logo are priceless," says Alan, "and that's why they don't endorse products or services. The next time you see a space movie or TV show, you'll notice the NASA logos are always slightly tweaked from the original. That's because we don't allow people to freely use the NASA logo for

Alan Kennedy served as a senior patent attorney for NASA, where he defended NASA's trademarks and intellectual property.

their own promotional purposes. This was a big deal in the '90s, when they were making movies like *Armageddon*, *Deep Impact*, and *Apollo 13*. As director of the infringement division, I worked on all those movies, to make sure everything they produced was in compliance."

Alan credits his Purdue education with helping him achieve success. "Yes, I have an engineering degree," he says. "Yes, I have a law degree. But what I really ended up doing in life? I'm a problem solver. That's what Purdue taught me. It gave me the ability to look at a situation, gather the data, and work with people to solve their problems. You can go into law with a degree in engineering; you can go into medicine with a degree in engineering. It just opens up so many avenues."

When Alan's fraternity (Kappa Alpha Psi) recently honored him with a lifetime achievement award, Alan returned to campus for the first time, and was shocked at the changes. "It was like Rip Van Winkle," he laughs. "I went to sleep, and when I woke up, everything changed! They have this beautiful Black Cultural Center. They have a Minority Engineering Program. Back then I was the minority engineering program!"

He continues: "I used to sit in my office on the top floor of NASA Headquarters, and from my window I could see the Capitol dome. I would pinch myself and say, 'why me?' For a little black kid from Kokomo, Indiana, that came here to Purdue, that they took a flyer on, it panned out! I put my work in, for sure. God provided the opportunity. But Purdue molded me."

ONLINE MASTER'S IS A SECOND

Same faculty. Same courses. Same degree. Less than $25,000. Purdue ME's new Online Master's program is the best of both worlds for working professionals.

As an engineer at 3M, **Andrew Penning** was pretty happy with his job – but he felt he could do more. With an Online Master's in Mechanical Engineering from Purdue, he found new opportunities to advance his career.

Andrew was raised on a farm in southern Minnesota; his father worked as a mechanic on farm equipment. "So I grew up taking stuff apart, and working on the mechanisms of engines," he said. He split his undergraduate degree between the University of Minnesota and University of Northwestern, St. Paul. He had planned to continue onto graduate school, but the opportunities in the working world were too good to pass up. "I got married while I was still an undergrad," remembered Andrew, "and got a really good job offer from 3M to work in computer modeling and simulation."

But after a few years, he found something was missing. "I was learning the industry side of things, but from the academic point of view, I was missing some of the fundamentals," he said. "And that's where Purdue's online master's has filled in the gaps, and really helped me with his work that I'm passionate about."

It also helps that he's taking the same Purdue classes with the same professors as on-campus students. "The education I'm getting is identical," said Andrew. "It's the same testing, it's the same grading, it's the same lectures. I'm just watching it online, when it's convenient for me."

"You have to maintain a balance," continued Andrew. "I'm expected to still do my full-time job, plus I've got a kid at home and one on the way. I spend time with my kid, put them to bed, and then I have to hammer down on studying."

And like any student, there are times when Andrew needs help with a specific subject. "Professors know when they are teaching an online class that their remote students are going to have questions," said Andrew. "They are active with email and with bulletin boards, and so are all the other students in the class. My advisor, Prof. Justin Weibel, is really great. Engineering school is hard either way, and you'll have trouble if you try to do it all yourself. Purdue encourages collaboration to help us all succeed."

Even though Andrew is still in the middle of the online master's program, it's already paid off for him. "It's opened doors into a new position for me on the research side here at 3M," said Andrew. "Corporate R&D is something I had always wanted to get into from the beginning, and this Purdue program has really enabled that to happen."

"Purdue has so many different course offerings," said Andrew. "I focus on the numerical side, but someone else may have another interest. Mechanical engineering is so broad and so flexible, that they have something for everyone. Purdue is so highly ranked in all their engineering disciplines, but to see them ranked #1 for their online master's program made me really happy."

BEST ONLINE PROGRAMS
U.S.News & WORLD REPORT
GRAD ENGINEERING
MECHANICAL
2020

Andrew Penning chose to pursue his career first, to support his family. Now with Purdue ME's Online Master's degree, he can pursue an advanced degree from home – which has already opened doors for him at his job at 3M.

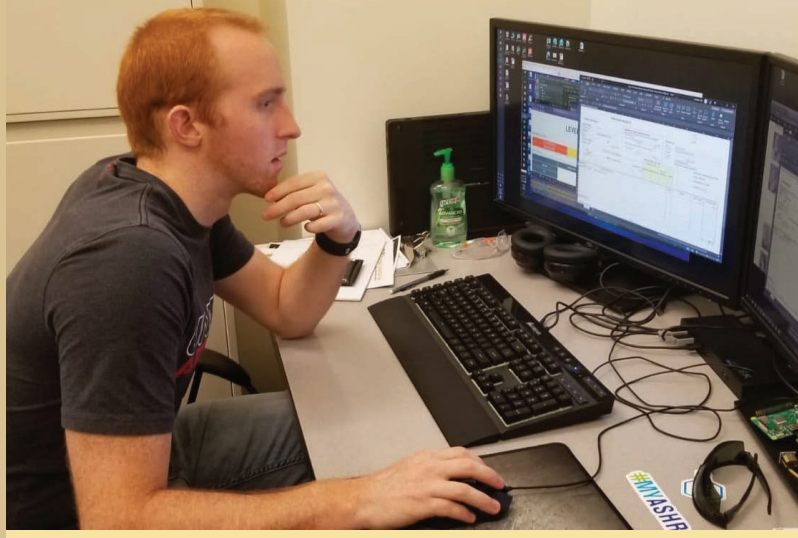
D CHANCE

ONLINE MASTER'S IS A STEPPING STONE

From a young age, **Jonathan Ore** imagined himself getting an advanced degree. But after earning a bachelor's from Penn State, he graduated into the worst recession in the U.S. in decades. Competition for PhD programs was fierce, and graduate school did not work out for him. He accepted that he would spend his career as a working professional at Westinghouse.

Then Jonathan discovered Purdue's Online Masters program for working professionals. Online students take the same classes with the same professors, and earn the same degree as students on campus. It can be challenging to balance a full-time career with advanced coursework on nights and weekends, but Jonathan found great benefit in the structure of the online degree program. His professors were understanding and accommodating, they were just as engaged with the online students as the on-campus students, and the program allowed flexibility in the coursework.

"The professors understand you're a working professional, and they are willing to work with you," he said. One week, just before a mid-term exam, he was visiting a factory in Mexico for his employer. An emergency at the factory required him to request special arrangements for his mid-term exam, and his professor accommodated his schedule. "I never felt I wasn't connected to the class or the professor just because I wasn't physically there," he remembered.



Jonathan Ore loved his Online Master's experience so much, that he decided to move to West Lafayette and finish a Ph.D.

Jonathan loved his master's experience so much, that he was convinced to move to West Lafayette and actually finish a Ph.D. in person. "When I got the acceptance letter for the Ph.D. program, I broke down," he said. "That an institution like Purdue, so highly ranked, would want me – I was blown away."

Prof. Eckhard Groll, who researches smart buildings, extended Jonathan a research opportunity for the DC Nano-Grid House: a project to retrofit an existing West Lafayette home from AC power to DC power to improve energy efficiency and reduce energy consumption. This project combines Jonathan's experiences in electrical and mechanical engineering – precisely what Jonathan set out to do years before.

He said, "Anyone can do this if you're willing to dedicate time and effort. And a degree can never be taken away from you."

Students in Purdue's Online Master's program watch the same lectures, do the same homework, and have the same access to faculty support as on-campus students.

Ranked #1 by U.S. News

Get your MSME for $22,500

100% online: Balance work, family, school

Your own pace: Finish a degree in 1-4 years

Enroll today! Learn more at

purdue.edu/ME/online

HACKATHON INNOVATIONS

USING DATA TO HELP LATIN AMERICA

Mario Trivella and Felix Fernandez had a lot in common – they were both Purdue Engineering students, both originally from Venezuela, and both spending their summer in Miami because of the lockdown. Why not take a weekend to collaborate on a virtual MIT hackathon to help Latin America?

The team ended up winning the competition with a new platform called ComuniMap. "Caracas, where we're from, has one of the largest slums in South America," said Mario. "These are makeshift homes that are put together quickly, and don't have an official address. There may be millions of people there who don't exist in any official record." During times of crisis like the COVID-19 pandemic, vulnerable communities in Latin America may not get the aid they need, simply because of faulty or non-existent census data. ComuniMap utilizes existing datasets, like cell phone coverage, topography, and nighttime satellite images. Using algorithms to combine the data, they produce a more accurate view of where people are living, even in areas that an official census may miss.

"I never thought that something we did just to be productive for one weekend would turn into this ambitious project," said Mario. "Now we're all dreaming about what this may become, if we put in the effort."

Mario Trivella (left) and Felix Fernandez (right) created a tool to map vulnerable populations in Latin America.

LEARNING FROM THE BEST

In happier days when hackathons could be held in person, junior **Morgan Fuller** was chosen to attend the Forbes Under 30 Summit in Detroit, Michigan. This summit brings together some of the nation's best young leaders, entrepreneurs, and innovators for immersive networking, learning, and development. Morgan represented Purdue University and the National Society of Black Engineers (NSBE). "I learned so much from engaging in workshops from dozens of founders, CEOs, and venture capitalists!" said Morgan. "I was also able to engage with some of the most diverse and young entrepreneurial talent across all industries. I really enjoyed the amazing sessions from celebrity founders such as Serena Williams, Kevin Durant, and Blake Griffin."

On the last day of the summit, Morgan competed in Erie Hack, a hackathon sponsored by the Cleveland Water Alliance. "My team was tasked with developing a start-up in 3 hours to reduce algae blooms in Lake Erie," said Morgan. "Our solution was a non-profit data-visualization service that incentivized clean farming to reduce nutrient pollution causing algae blooms. I am so lucky to have worked with an amazing and talented team that made it possible to win first place!"

2019 was a big year for Morgan. He worked as a Process Engineer Intern at Tesla Motors, and managed NSBE's Motorsports team, who finished the Purdue Grand Prix go kart race for the first time in a decade. Said Morgan, "I'm truly blessed to be able to learn from so many talented people!"

Morgan Fuller (far left) collaborated with young leaders and innovators across the country to win a hackathon at the Forbes Under 30 Summit.

STICK BOMB SCIENCE

Fun with finite element analysis

Stick bombs are chain reactions made by interweaving popsicle sticks in a specific pattern. They are also an ideal illustration of pre-stressed structures found in nature, such as the twigs in a bird's nest, or certain molecular structures that demonstrate the same geometry. Prof. Thomas Siegmund received a grant from the National Science Foundation to model these microscopic configurations using macroscopic materials, and found that stick bombs were a perfect analog.

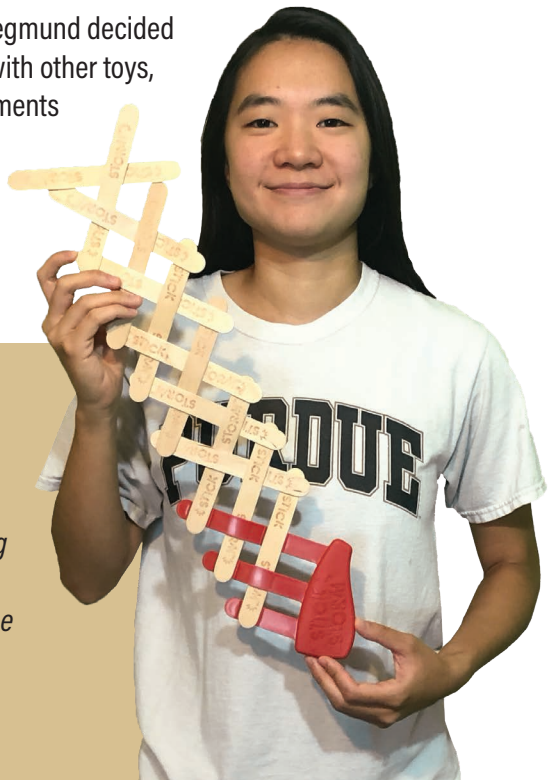
"This was a new experience for me," said **Lucas Allegrette**, an undergrad student recruited by Siegmund. "I didn't have any experience using finite element analysis. But the research was so interesting, I decided to go for it."

Lucas started by modeling a frame bomb, where a small number of sticks are held together in the shape of a square, triangle, or star. "The model clearly showed that along undeformed regions of the sticks, there was very little strain," he said, "but in highly deformed regions like the center, there was a large amount of strain."

Then he moved on to a more complex pattern, the cobra weave. "The cobra weave is a long chain of sticks that are interconnected," Lucas explained. "When you release a stick at one end, it actually creates a wave that travels from one end to the other. We were able to measure and quantify these wavelike properties."

When Lucas' research won awards at an ASME conference in November 2019, Prof. Siegmund decided to expand the scope of the work. In the summer of 2020, he organized research projects with other toys, such as wooden blocks and Lego bricks. Working from home, students conducted experiments with the toys to demonstrate principles of fracture mechanics, force vs. displacement, and wave propagation – which could then be used to teach those concepts to others.

"You wouldn't expect that a children's toy, like a stick bomb, could be related to molecular microstructures," said Lucas. "You'd be surprised how well you can relate two dissimilar things, and find something out about the world."



Students Reese Staples (left) and Grace Szymanski (right) spent their summer researching the cobra weave, which demonstrates a wavelike release of strain energy.

FUTURE OF VACCINES

Bio-inspired and pain-free

Michael Schrader (BSME '04) attended Purdue because he wanted to work in the automotive field. But instead he found himself as CEO of a new medical startup company, Vaxess Technologies, developing a medicine-delivery patch that only needs to be worn for five minutes to deliver a full dose.

"The biggest challenge for me was that I hadn't taken biology classes since my freshman year of high school!" laughs Michael. "Now we're developing a product that delivers vaccines and cancer treatments. But the biggest aspect of a Purdue education is that they teach you how to learn, so you can pick up new fields very quickly."

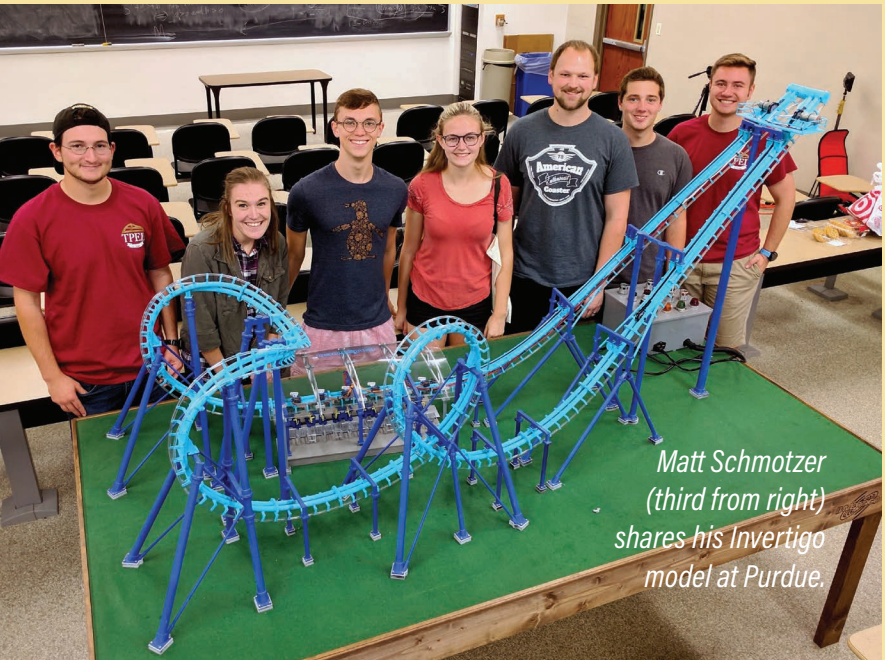
The patches are made from a novel biomaterial derived from silk. When the patch is applied to the skin, tiny silk micro-needles deliver medication at a customizable dose. These could include a wide range of medications, including vaccines, without the need for painful injections. "Moving into the world of healthcare has been amazing," says Michael. "We've been fortunate to work with organizations like the National Institutes of Health, and the Bill & Melinda Gates Foundation. It gives you that little bit of extra incentive to overcome tough problems, because you know what you're working on matters, and has the potential to positively change people's lives around the world."

PRINT MY RIDE

3D printed roller coasters are just the beginning

By day, **Matt Schmotzer** (BSME '12, MSE '17) is a Product Development Engineer at Ford Motor Company. At night, he becomes amateur roller coaster builder! "It's what originally drove me to become an engineer," said Matt. "I've always had this crazy dream of designing roller coasters. At Purdue, I learned computer-aided design, laser cutting, and 3D printing – and now I can make it happen!"

His first attempt was a 1:25 scale model of *Invertigo*, a coaster at Kings Island in Ohio. Using a combination of Google Maps, photos, videos, and his own intuition, he successfully designed the entire coaster in SolidWorks, right down to fully functional entrance gates and passenger restraints. With each track section taking about 12 hours to print, Matt spent several weeks on the final assembly – but the results spoke for themselves. "When I first saw that it worked, and the cars ran like they were supposed to, it was the best feeling ever!" Matt remembered. He even brought his creation to Purdue, sharing it with students as part of their Theme Park Engineering and Design group.



Matt Schmotzer (third from right) shares his Invertigo model at Purdue.

Matt has built on that success with Print My Ride, a business that sells coaster models online and teaches others how to design and 3D print their own. And he's still building! His 1:42 model of *Steel Vengeance* is on display at Cedar Point in Ohio. He assembled his version of Six Flags' *Batman: The Ride* in person at a SolidWorks convention. He even built a Rube Goldberg machine as part of a photo shoot for *Car and Driver* magazine.

"Seeing people's reactions has been amazing," said Matt. "I hope it inspires them to think, 'Hey, I've got a 3D printer, I can go and make this!' "

GIANT LEAPS

More astronauts have their bachelor's from Purdue than from any other school. In 2019, many of them returned to campus for an Astronaut Reunion, including **Jerry Ross** (left, BSME '70, MSME '72), who set records with seven Space Shuttle missions and nine spacewalks; and **Scott Tingle** (right, MSME '88), who spent 168 days aboard the International Space Station. The two spoke in several ME classes, were honored at halftime of the Homecoming football game, and toured the latest advancements at Zucrow Labs, where they had done their own graduate research in fluid mechanics and propulsion.

TO THE MOON!

The first and last people to walk on the Moon were Purdue engineers. The next humans to walk on the Moon will be wearing a spacesuit designed by Purdue engineer **Amy Ross** (left, BSME '94, MSME '96). She recently showcased the new xEMU spacesuit, which offers extended flexibility and protection for astronauts to explore the Moon as part of NASA's Artemis program.

Amy also has her sights set on Mars. She has sent the first ever samples of spacesuit material to the red planet, where they will be tested aboard the Perseverance rover, scheduled to land on Mars in February 2021.

RESEARCH HIGHLIGHTS

'LIQUID BIOPSY' DETECTS CANCER FROM A SIMPLE BLOOD DRAW

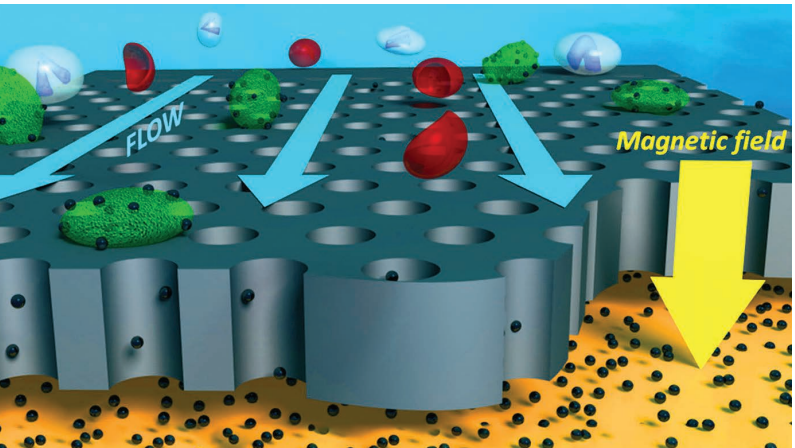
Accurately diagnosing the spread of cancer often involves painful and invasive biopsy procedures. Now thanks to a landmark 5-year clinical trial and a device created by **Prof. Cagri Savran**, the use of a "liquid biopsy" involving a simple blood draw has been shown to accurately detect and monitor certain kinds of breast cancer.

The study involves circulating tumor cells (CTC), material from tumors that find their way into the patient's bloodstream. "These CTC cells are extremely rare," said Savran. "In a blood sample of eight milliliters, there are billions of cells, but the cells we're looking for, there may only be three or four."

Savran and his team developed a liquid biopsy device to isolate these cells. They mix blood samples with magnetic particles, functionalized with antibodies to recognize the cells they are targeting. Then they run the samples through a microfluidic device, which has a magnetic field that attracts and captures only the magnetized CTC cells. "Once we've got them, we can do a number of things," Savran said. "We can culture them, we can run tests on them and, most importantly for this trial, we can count them. The number of cells in a sample has a significant meaning."

As part of a collaboration with IU Simon Comprehensive Cancer Center in Indianapolis, the device was tested in a clinical trial of patients with a particularly aggressive form of breast cancer. The detection of CTCs turned out to be a better predictor of recurrence than any other clinical indicator currently used today. A paper on the clinical trial's results has been published in the American Medical Association's journal *JAMA Oncology*.

"It's very important to me and my team of engineers that the things we build are really useful," Savran said. "This technology is being used on real patients and now has the power to make a real difference."



WHY ARE MICROBES ATTRACTED TO AN OIL SPILL?

In April 2010, a catastrophic explosion aboard the oil rig *Deepwater Horizon* caused an underwater wellhead to rupture, discharging oil into the Gulf of Mexico. It took 87 days to cap the underwater well, by which point more than 200 million gallons of oil had discharged into the gulf. Officials used many different tactics to contain the damage of the oil spill, including the somewhat controversial use of dispersant (or surfactant) chemicals to break up oil slicks. However, they found that this made it easier for microbes to digest the hydrocarbons.

"Microbes were the 'first responders' to the oil spill," said **Prof. Arezoo Ardekani**, who conducts research in complex fluid dynamics. "They remediated a significant amount of hydrocarbons. But the Gulf of Mexico is a big place. How did so many microbes find this oil?"

As Ardekani discovered, the surfactant actually created a hydrodynamic phenomenon that caused microbes to gather in even greater numbers than expected. "Those surfactants changed the interface property," Ardekani said. "If microbes are hydrodynamically attracted to gas-liquid interfaces, the presence of surfactants made it even more attractive." Her research was recently featured on the cover of the journal *Soft Matter*.

"We didn't know any of this before the spill," Ardekani said. "The main reason they used dispersants was to break up the size of the oil droplets. But now we have discovered a new hydrodynamic mechanism, that adding surfactant causes microbes to spend more time near oil droplets. That, combined with chemotaxis, may potentially give microbes more time to decompose these hydrocarbons."

HELP FOR SWALLOWING DISORDERS

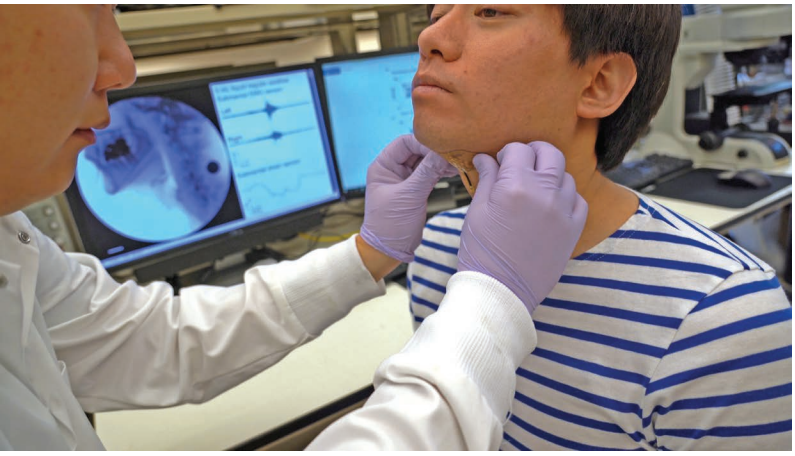
More than 9 million Americans experience severe swallowing disorders each year, and many don't have the resources to visit a clinic for help. **Prof. Chi Hwan Lee** created a wearable device allows patients to conduct strengthening exercises at home, sending their feedback to a doctor remotely.

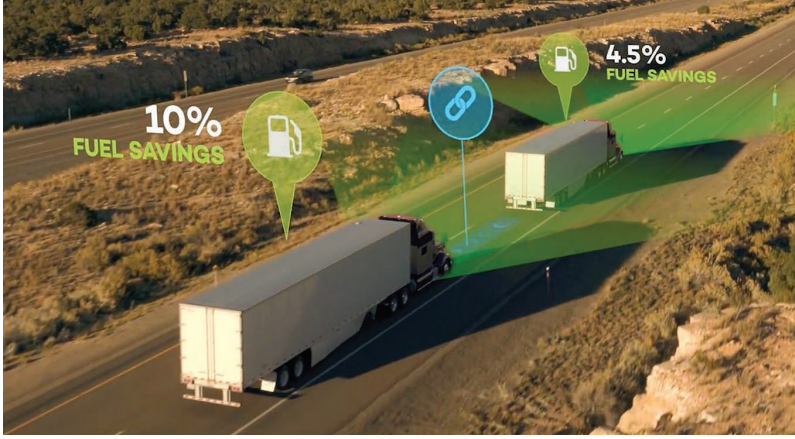
"The measurement of the swallowing function is very challenging, because it involves more than 60 different muscles," said Lee. "A disruption in any of these pathways can result in a swallowing disorder, adversely affecting the patient."

Lee's solution was to create a sensor sticker, which patients can apply to their own skin to monitor specific muscle activity. "Our device is unique in that we specifically created it to work well with these small and intricate muscles," said Lee. "The sensor sticker is stretchable and flexible to work well with the skin and curvilinear head and neck shape, while the connected unit has the electronic chips and communication components."

Lee collaborated with the College of Health and Human Sciences to test the devices on real-world patients. After applying the patch, they conducted their swallowing exercises, with the sensors recording feedback to an external device. That data was sent electronically sent to their doctor, who could then provide feedback. Lee's team also developed software to visualize the data, enabling patients to be involved in monitoring their own progress in real-time.

"We want to provide a reliable, patient-friendly and affordable way to treat the millions of people with swallowing disorders," Lee said. "Our goal now is to reduce the manufacturing cost, and make these devices affordable and easy-to-use for everyone."





PLATOONING MAKES TRUCKS SAFER AND MORE FUEL EFFICIENT

Purdue is addressing an overlooked sector in autonomous transportation: tractor-trailers haul about 70% of the nation's freight, and use about 25% of the nation's fuel. **Professors Greg Shaver and Neera Jain** are collaborating with industry and government partners to advance platooning technologies, where one truck autonomously follows another at close range.

"Platooning reduces fuel consumption, through decreased aerodynamic drag for both the lead and follow truck," said Shaver. "By improving fuel economy, platooning reduces cost and CO2 emissions. In addition, platooning improves safety, due to constant vehicle-to-vehicle communication, and advanced braking systems which have much faster reaction times than a human driver."

Purdue is working with Peloton Technologies, Cummins, and Peterbilt to demonstrate the benefits of platooning. Specifically, the Purdue team is developing the control algorithms for ideal acceleration, braking, and follow distance for platooning trucks. "We've shown that this system enables up to a 15% fuel savings, even in hilly terrain," said Shaver.

They are involving multiple stakeholders in the development and adoption of the system. As one example, they recently worked with the states of Indiana and Ohio to secure a $4.5 million federal grant to research how truck automation technologies could be implemented in the two states. "We are eager to collaborate with fleet owners, truck manufacturers, technology providers, legislators, and truck drivers to advance this technology, to save fuel and to save lives," said Shaver.

PURDUE UNIVERSITY
Mechanical Engineering

585 Purdue Mall
West Lafayette, IN 47907
purdue.edu/ME

Non-Profit Organization
U.S. Postage
PAID
Purdue University
Permit No. 221

You can't spell Boilermaker without "maker." During the COVID-19 pandemic, Prof. Mukerrem Cakmak (right) converted his roll-to-roll manufacturing testbed into a factory, laser-cutting thousands of personal protective equipment items for local health workers, with raw materials donated by 3M.