Autumn 2023

MESSENGER

MECHANICAL ENGINEERING | UNIVERSITY *of* WASHINGTON

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CHAIR'S MESSAGE

Welcoming new students and faculty

This fall, I am incredibly happy to welcome more than 200 juniors and 186 sophomores into our competitive major. We will be first-row witnesses to their next years as they join our award-winning student clubs, pursue research and make key connections with classmates, mentors and our industry partners.

I'm also pleased to welcome new additions to our talented faculty. In last spring's issue, you met four new faculty members, and here we introduce you to two more. Our new faculty are advancing research in areas such as advanced materials, jet and rocket propulsion and data science. They're applying their expertise to expand our knowledge of tissue regeneration, clean energy technologies and more.

Every day our faculty are working with ME students in classrooms and labs, and guiding students on design-build-test teams. Their work ensures that ME graduates will continue to make an impact across our state, nation and world.

Alberto Aliseda
Mechanical Engineering Chair
PACCAR Endowed Professor

Welcome new faculty members

Renee Desing joined ME this fall as an Assistant Teaching Professor focused on diversity, equity and inclusion (DEI). Desing earned a Ph.D. in engineering education from The Ohio State University and has worked in industry, consulting and as a postdoctoral researcher at Ohio State and Oregon State University. She holds a B.S. and M.S. in industrial engineering from the Georgia Institute of Technology and Pennsylvania State University, respectively.

John Palmore Jr. will join ME as an Assistant Professor. He researches computational strategies to simulate droplet-laden and particle-laden fluid flows. This research addresses a variety of engineering problems in aviation, energy, the environment and biomedicine. Previously he was an Assistant Professor of Mechanical Engineering at Virginia Tech, a postdoctoral researcher at Cornell University and a graduate researcher at Cornell University. He holds Ph.D. and M.S. aerospace engineering degrees from Cornell University, and a B.S. in aerospace engineering from the University of Alabama.

ME EXTERNAL ADVISORY BOARD

Thanks to the following alumni and friends for participating on the 2022-23 board:

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Angela Templin, '99 BSME, Vice President, Glumac
Jon Yourkoski, '96 BSME, Morgan Stanley & Co. Inc.

Student club successes

Husky Robotics takes second place

In August, the Husky Robotics team won second place in the 2023 Canadian International Rover Challenge in Alberta, Canada. Each year, Husky Robotics builds a mock Mars rover to participate in competitions during which teams simulate the experience of being an early colony on an extraterrestrial planet. Teams perform challenging tasks with their robot such as traversing rocky terrain, redirecting water, taking soil samples and completing a search and rescue mission.

UWHPS receives runner-up award

UW Human Powered Submarine made a splash at the 17th International Submarine Races in Maryland. The team's Orca submarine received the runner-up award for overall performance, which judges not only speed but a presentation, design report and the team's ability to answer questions about the submarine. The team was also second place for speed in the one-person propeller college division.

ARUW wins 3v3 confrontation

In July, Advanced Robotics at the University of Washington (ARUW) won the 3v3 confrontation and finished third place in the 1v1 competition at the RoboMaster North America competition, held at the UW. Each team designed and built robots that battled by launching plastic projectiles at plates to deduct hit points. This year, ARUW built its first self-balancing robot. To construct their design, ARUW team members became skilled in controls theory, modeling and design.

Formula Motorsports takes third place

Each year, UW Formula Motorsports designs, builds, tests and competes with an electric formula-style race car. In June, the team came in third place overall out of more than 60 teams in the Formula SAE Electric competition in Michigan. They were scored based on presentation, design, acceleration, efficiency and more. The students passed all technical inspections in record time, and they came in second-place in the presentation event.

Xu Chen appointed director of BARC

Xu Chen, Bryan T. McMinn Endowed Associate Professor of Mechanical Engineering, began his appointment as director of the Boeing Advanced Research Collaboration (BARC) in September. He will help develop the vision and mission for this collaboration, integrating the Boeing Advanced Research Center, the AI Center for Dynamics and Control Research & Education, and industry capstone and sponsored research programs.

BARC builds on the Boeing Advanced Research Center, where since 2014 Boeing engineers have worked alongside engineering faculty and students on projects in aircraft manufacturing and assembly. Chen leads the collaboration's efforts to make a substantial impact in new materials research, manufacturing and workforce development.

HUMAN-INSPIRED ROBOTIC PERCEPTION

An ME Ph.D. graduate's research aims to improve visual perception in autonomous robots.

Ekta Samani (M.S. '21, Ph.D. '23) envisions robots someday being able to navigate new environments to perform useful tasks. One example is sorting recyclable and non-recyclable materials at waste facilities, where items are constantly changing and unpredictable.

Typically, robots navigate spaces that are designed for their operation, including warehouses and grocery stores where items are neatly organized. Robots are trained to identify items by repeatedly looking at different object placements. While this method works for structured areas, it fails in cluttered environments, such as recycling facilities. This is partly because it's impossible to train a robot on every object placement it may encounter.

To solve this challenge, Samani developed a method that emulates human object recognition in robots.

"Using computational topology tools, I develop methods for robots to operate in environments that are unknown to them, so they can operate in our homes or another new environment," she says. "My methods are also inspired by human perception. I researched cognitive development in infants to see how they develop some of these skills."

Combining topology and cognitive psychology

Topology is an area of mathematics that studies the connectivity between different parts of objects. Samani uses computational topology-based methods to capture an object's underlying shapes. This helps robots build representations of an object's appearance.

Samani also replicated in her robot how humans reason about the hidden portions of partially obscured objects to recognize them.

"Humans compute representations of every object they see," she says. "These representations encode information such as shape and visual appearance. To recognize any object, they match its representation with those in their memory. I replicated that reasoning mechanism into my framework so the robot can use it to perceive objects in cluttered spaces."

Samani trains her robot, shown above, to recognize partially obscured objects in new environments.

In recent experiments, Samani showed a robot computer-generated pictures of all the objects it could potentially see in her research lab, which the robot stored as references. The lab, where common household objects were placed on shelves, was a new environment for the robot. Using Samani's methods, the robot could recognize items, even when they were partially obscured, by matching partial objects it saw with pictures of the complete objects.

Samani hopes her work is one step toward enabling robots to sort waste into recyclable and non-recyclable materials, a task that can be unsafe for people when it involves sharp objects or hazardous materials. When Samani recently tested her method in the lab, the robot successfully recognized the objects in the trash can.

Today, as a postdoctoral researcher at Amazon, Samani is expanding her knowledge of topology and applying it to automation problems. She hopes to continue researching robotics and automation with one goal in mind: "I want to make a positive impact on people's lives," she says. ■

Samani at the 2023 ME graduation with her longtime mentor Ashis Banerjee, ME and ISE associate professor.

Ben Price adjusts the current on the power supply box to apply voltage across a plasma actuator, shown on the right.

DISCOVERING A PASSION FOR RESEARCH

Studying electrical flow sparked an ME student's decision to pursue graduate education.

Story by Lyra Fontaine
Photos by Dennis Wise/University of Washington

Ben Price (BSME '23) hadn't planned to attend graduate school. But after working as a research assistant for the Novosselov Research Group (NRG) and receiving support from scholarships, he changed his mind.

"I realized that I am interested in developing new technologies, designing devices and learning new things," he says. This fall, Price began his first year as an ME graduate student.

Real-world research experience

Price studies electrohydrodynamics, the flow of electrically charged particles or plasma. His team applies a high voltage across an actuator that uses the electrical current to change the flow of air. They then research the dynamics of the plasma created by the process. The goal is to enable the actuators to actively modify flow for potential applications such as improving aircraft structures' aerodynamic performance. One example of active flow control is the flaps on the back of an airplane wing, which can extend, retract and bend, thus affecting the behavior of the aircraft.

Long-term, Price is interested in using plasma to study fluid dynamics. He contributes to research in the NRG lab that uses plasma to destroy "forever chemicals," or per- and polyfluoroalkyl substances (PFAS), which persist in the environment and may have harmful health effects.

"I cannot stress enough how important it is for up-and-coming engineers to get experience with real problems that don't have a direct solution online or in a textbook," he says.

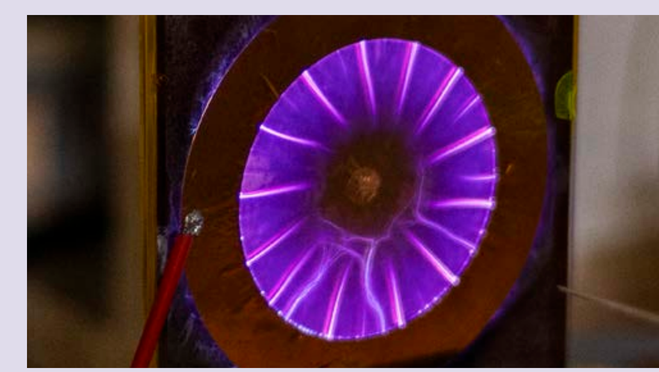
Pursuing a Ph.D.

Both Price's positive research experiences and the UW's financial support played a role in his decision to pursue a Ph.D. In addition to receiving a Mary Gates Research Scholarship, he is eligible for the Husky Promise, which guarantees eligible Washington state students grants and scholarships that fully cover the cost of the UW's tuition.

"The financial support guaranteed by the Husky Promise has changed my trajectory and enabled my education and experiences," Price says. "As I came close to graduating and seriously considering further education, I realized that it would be financially possible at the UW, thanks to the support of the ME department."

Now as a graduate student, Price is building upon his electrohydrodynamics research in the NRG lab by improving actuator design efficiencies and finding new ways to model complex systems. He's working on manipulating flow over aircraft wings, and his team will soon work to implement the active flow control methods on aircraft and other structures.

"We're working to answer questions that have never been answered before," he says. ■



The purple streaks of light indicate a high energy discharge where electrons flow through. Typically the researchers try to apply as much voltage as they can without getting them.

Monitoring for marine life

A team is testing new methods to assess the potential impacts of tidal turbines on marine mammals.

Story by Lyra Fontaine
Photos by Mark Stone/University of Washington

UW and PNNL researchers placed a tidal turbine with sensors, along with a silicone whale model, inside a wave facility at the Harris Hydraulics Lab. They gathered data from the model's collisions with the turbine, with the goal of making sure that tidal turbines are safe for marine mammals.

Marine renewable energy is power generated from the movement of water, such as waves, tides and currents. If harnessed, it could help significantly in meeting energy needs in the United States. Because ocean tides are created by gravitational forces and the Earth's rotation, tidal energy in particular has the potential to be a consistent and reliable source of power.

One way to convert tidal energy is through a turbine, which can either be suspended from a floating platform or be placed on the seafloor. The motion of tides rotates the turbine's blades, which then powers a generator.

However, before accelerating the use of turbines and other underwater technologies, regulators and communities want to ensure the safety of tidal turbines on marine mammals. That's where researchers from the UW and the Pacific Northwest National Laboratory (PNNL) come in.

"It's exciting to contribute to making sure that renewable energy technologies don't harm the underwater environment," says Molly Grear (CEE Ph.D. '18), a PNNL ocean engineer and ME affiliate faculty member who co-leads the project.

The team is working on campus in a controlled, simulated environment at the Harris Hydraulics Laboratory to assess whether it's possible to use sensors integrated into turbine blades to detect collisions between marine mammals and turbines.

Studies examining the presence and behavior of fish around marine energy devices suggest collisions are rare, but there are still knowledge gaps around the probabilities and consequences of collision events. The researchers hope to develop tools to better understand, and potentially reduce, the impact of turbines on marine life and ensure that testing marine energy devices in the ocean is safe for animals.

A new way to monitor marine life

As a graduate student, Grear researched the potential impacts of turbines on marine mammals. Through computational modeling, her findings indicated that not all collisions harm animals and that the likelihood of hitting a turbine blade based on animal swimming speeds and rotational rotor speeds is low. The researchers are building on these results in the lab by developing new approaches to detect and measure the impact of collisions if they do occur — data that, until now, have been challenging to collect.

"It's difficult to monitor for collisions, because tidal turbines are typically installed in energetic, hard-to-see environments," says PNNL and ME ocean engineer Emma Cotter (ME Ph.D. '19), the project's co-lead.

Previous research has developed instrumentation systems to monitor animals at marine renewable energy sites using a variety of sensors, including cameras and imaging sonars. At the UW, Cotter contributed to developing a system that detects underwater marine life at wave and tidal energy sites.

However, acoustic and optical sensors can't measure the force of a collision, which can provide insight into the level of impact on an animal. That's why the researchers decided to attach a monitoring system to the turbine itself — a new way of gathering underwater collision data.

They placed tiny electrical sensors called strain gauges, which are typically used to measure the forces on a structure, onto a tidal turbine's blade. The strain gauges' voltage changes when force is applied. For example, poking the blade increases the strain and thus the voltage.

"It felt like a step forward to monitor marine life by using a strain gauge, which might already be on a tidal turbine blade to monitor its performance," Grear says.

Collecting collision data

The researchers, including UW research engineer Isabella Pestovski (ME M.S. '23), conducted hands-on experiments this past summer to test if the sensors could detect collisions.

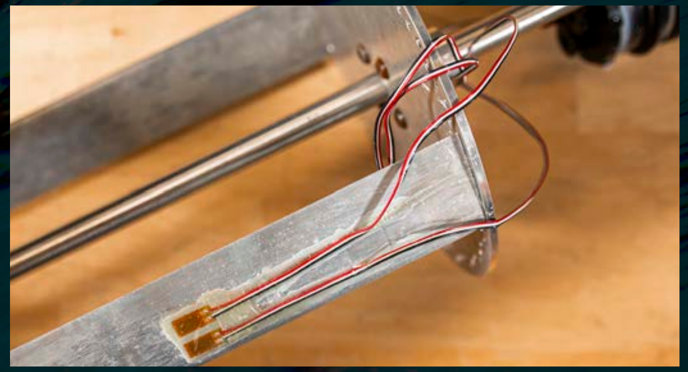
They placed the turbine and a silicone whale model nicknamed "Whaleon Jennings" inside a flume, which is a facility with controls for the flow speed, depth and temperature of the water in the tank. Although the silicone whale models don't represent marine mammal behavior, they allowed the researchers to perform repeatable experiments that simulated the force on the turbine blade if a collision were to occur.

"The goal was to collect the strain data and see to what extent these impacts are detectable," Pestovski says.

From the experiments, the researchers confirmed that head-on collisions were identifiable in the strain data. The sensors can also potentially detect the presence of an incoming marine mammal since the silicone whale blocked the turbine blade's fluid flow — similar to a rock blocking water flow in a river.

Understanding the environmental impacts

Pestovski's machine learning knowledge enables her to quantify the force of impacts through data analysis. The team's next steps are to improve experimental setup for further research and examine how the data can inform turbine control algorithms to reduce the impact of collisions if they occur. They also plan to investigate how these preliminary results can apply to full-scale turbines deployed in the ocean.



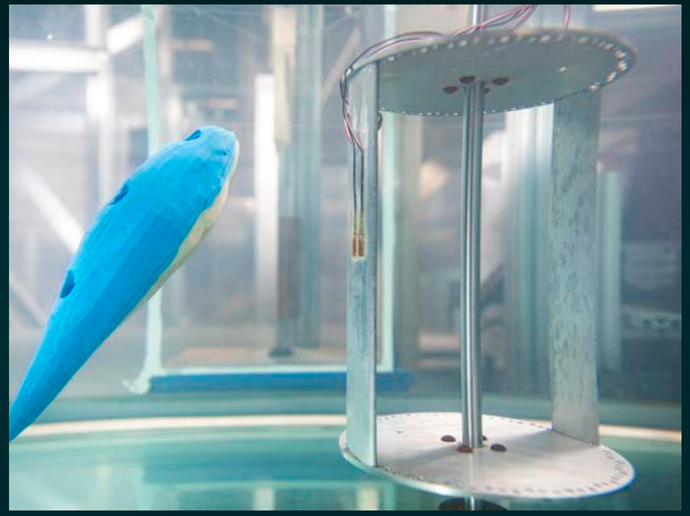
The researchers mounted tiny electrical sensors called strain gauges onto a tidal turbine's blade.

Early results show it might be possible to use data from the sensors to control the turbine's operation, so the blades could move at a slower speed when the sensors detect an oncoming collision. This could have less impact on a mammal.

By developing a new approach to detect collisions and measure the potential impact of a blade strike, the team's research could lower costs and other barriers to testing marine energy technologies.

Throughout the experiment, Pestovski has been drawn to the ability to make a difference in marine energy research.

"Before this research, I'd never worked on or considered environmental problems for renewable energy solutions," she says. "I'm excited to continue to work on this project to help make marine energy technologies more accessible and usable." ■



The researchers confirmed that the sensors on the blade can identify head-on collisions to the turbine. Eventually, they hope to use the sensors to slow the turbine when the sensors detect the silicone whale model approaching.

ACHIEVING LIFTOFF

Caught in a cycle of addiction, homelessness and prison, Raymond Haug transformed his life and found a calling in mechanical engineering.

By Jamie Swenson

Raymond Haug, '23, in the ME machine shop. Photo by Dennis Wise/University of Washington

The last time Raymond Haug got out of prison, in 2016, he had no friends or family waiting to pick him up. He had no new clothes to change into. All he had was his state-issued prison sweatsuit, a brown paper bag with his housing voucher paperwork, and a faint glimmer of hope.

A prison guard dropped him off at Everett Station, where he reflected on his years of homelessness, addiction, crime and incarceration. Fighting intense shame and doubt, he considered the monumental goals ahead of him: Stay sober and get an education.

Then he stood up and walked to Everett Community College (EvCC) to apply for admission.

A life transformed

Seven years later, Haug has transformed his life. He recently earned his UW undergraduate degree in mechanical engineering, completing two SpaceX internships along the way. He's now a transportation engineer with the Washington State Department of Transportation, and he'll begin the UW ME master's program in fall 2024. His wife, Althea, just completed her master's in teaching at the UW. They have two young children.

Respected by his professors and peers, Haug earned several scholarships that made his education possible at EvCC and the UW. "The awards make me feel like I do belong in school," says Haug. "It's helped me live the life I'm living now."

But "Old Ray," as he calls his past self, will always be part of him. Because of his prison time, Haug has never been approved for an apartment rental and was repeatedly turned down for jobs. When he used a computer at the EvCC welcome center to apply, he half-expected security to escort him out.

"Coming from the world I did, recovering from addiction," he says, "my brain still tells me I don't deserve the life I'm living."

When he started college, Haug felt he had to hide his past. But when an EvCC professor, seeing his talent for math and chemistry, urged him to apply for a job in the tutoring center, Haug had to sit down with human resources and go over his history of addiction and crime. He got the job — and saw the value of sharing his story.

Breaking the cycle

When Haug was 5, his father died of a drug overdose. As a teen, Haug was in and out of juvenile detention. At 15, he was sleeping under Montlake Bridge. He held up cardboard signs on the street corner and worked odd jobs. But as his heroin addiction progressed, he turned to crime, receiving the first of several robbery sentences when he was 18. So began a brutal cycle of incarceration, release, relapse and re-incarceration.

Years later, when he found himself locked in the same solitary-confinement cell during two consecutive sentences, something clicked: "I decided that if I was going to get it together, I had to do so in prison — not when I was back out on the street."

In a drug treatment course in prison, Haug learned of the Post-Prison Education Program (PPEP), a nonprofit that helps connect the formerly incarcerated with postsecondary education.

PPEP helped him get his college financial aid application in order. Then he was released.

You *can*

Before long, Haug was living in sober housing, volunteering with Narcotics Anonymous, enrolled at EvCC and working as a tutor. He also taught himself how to fix up cars and motorcycles. One day in chemistry class, Haug showed his professor photos of a motorcycle he was building.

"He was like, 'Why aren't you an engineering major?'" remembers Haug. "But I had never heard of engineering."

After deciding to major in engineering, he began applying for and receiving scholarships, sharing more of his background each time. Then he told his story as a speaker at a scholarship breakfast. He remembers how it felt, with a supportive audience listening to his every word.

"I was so grateful to be respected by my peers who weren't from prison," says Haug. "The impact they had — all they had to do was tell me, 'You can.'"

Launchpad UW

As Haug set his sights on transferring to a university, he was awarded a scholarship for students at Washington state community colleges who hope to complete their bachelor's degree at the UW. Haug was drawn to the university's strong ME program and the UW Formula Motorsports Team, a student organization that designs, builds and competes with electric formula-style race cars. It was his launchpad to landing two internships with spacecraft company SpaceX, where he worked on the pressurized ground systems team. Haug brought his problem-solving to the forefront there. "My background fits into that divergent thinking they want to grow," he says. "I'm a good fit because I've had to be so adaptive my whole life."

Change is possible

Haug was thrilled to help build ships that go to space, but he's equally committed to making a difference on Earth, helping others find their way to a brighter future.

Haug has enjoyed mentoring youth involved with the criminal justice system. Last October he spoke at a conference for STEM-OPS, which works to include STEM learning opportunities in prison. "It's my responsibility to help," he says. "What's the point of making it if I don't help the person behind me?"

Haug and his family take the stage at his 2023 graduation. Photo by Matt Hagen

A dream realized

In June 2023, Haug — holding his daughter's hand and his son in the other arm — strode across the stage to loud applause at the ME graduation. His daughter reached out and accepted his diploma for him. It was the first time Haug had ever walked in a graduation.

"My world was so small when I started going to college," Haug says. "I wouldn't have been able to predict where I'd be right now." ■

From idea to implementation

Through ME's undergraduate capstone program, students gain real-world experience on projects that help industry, nonprofit, government and health-care partners.

Students have a diversity of projects to choose from, but they all share the experience of going through a full-cycle design process, from defining the problem to prototype fabrication and testing. Below, we highlight three 2022-23 capstone teams that made their brainstorming, research and sketches come to life.

Seaweed solutions

In the summer and amplified by climate change, excess Ulva seaweed grows in the Puget Sound and covers shellfish cultivation gear, becoming a burden for farms such as Calm Cove Shellfish in Shelton, Washington. The quickly growing seaweed can suffocate farmed shellfish and can negatively impact local water quality when it decomposes.

In collaboration with the nonprofit organization Puget Sound Restoration Fund and Calm Cove Shellfish LLC, ME students developed a device that helps dry the seaweed so that it can be more easily removed and used for different purposes such as compost material.

After 3D modeling the device, the team created the press using lumber. To use the device, a long mechanical arm is pulled down, which applies pressure to a five-bar linkage, a mechanism that can expand or contract. This lowers a circular press that squeezes the water from a basket of wet seaweed, making the seaweed lighter and easier to transport.

The device could remove more than 35% of water from the seaweed, if the structure were stronger and made out of more durable materials. The students presented their results to the shellfish farmers who had provided input throughout the process.

"The employees liked how it was easy to use and pressed out a decent amount of water," team member Joe Condit says.

The students also made recommendations for the device's next iteration and created a manual that explains how farmers can construct the affordable and accessible design themselves.

Students demonstrate how to use the mechanical press they created to help dry seaweed. Photo by Eli Patten

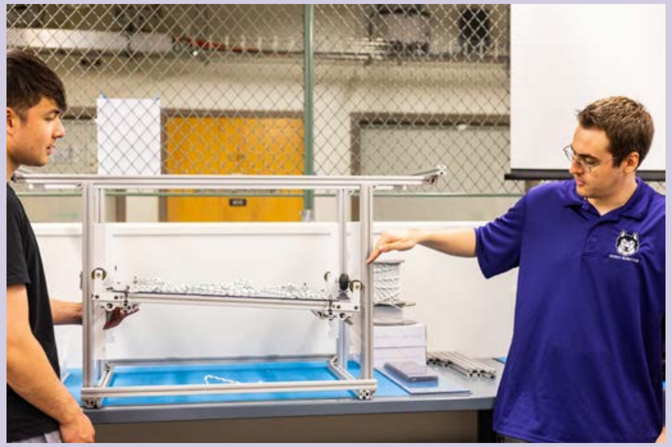
"I like how the project is community-based and solves a real problem," says team member Emily D'Arcy. "This isn't a project that will just be filed away."

The team was recognized with the 2023 Outstanding Design Award at the ME graduation ceremony.

Adjustable height test load tower

Hyster-Yale Group manufactures lift trucks, which are used for raising and carrying heavy materials. To test and validate critical structural components and truck functions, the company runs instrumented trucks on test courses that include moving loads on and off elevated platforms. The platforms are non-adjustable, so employees must use different structures to test lift trucks with different lift height capabilities.

Looking for a more efficient way to achieve unique platform heights for specific tests without stacking or creating new fixed height towers, the company tasked a capstone team with finding a solution.



Zach Oropesa and Jordan Smith showcase their scale model of an adjustable test load tower. Photo by Raymond Smith/University of Washington

The team successfully designed a platform for a test load tower that can quickly adjust in height from about six-and-a-half to 16.4 feet. The full-scale model can hold 11,023 pounds. The students constructed a scale model of their design to demonstrate how it works.

When designing the prototype, the students considered safety, reliability and ease of operation. They then cut each piece of aluminum and 3D-printed plastic to size in the ME machine shop. Wheels on each side of the platform keep the load surface-level while it is raised. When the platform gets to the top, a spring resets it so the platform can be lowered. The students used skills they learned in class to design the spring and calculate how the structure would perform under different real-world conditions.

"It was rewarding to see our design that started on paper come to fruition and become a scale model," says team member Zach Oropesa.

SmarTrach

A child who needs help breathing might undergo a tracheostomy, a procedure that creates a small hole in the front of the neck and the windpipe. A small tube is placed into the opening and connects to a manual airbag or breathing machine. This enables the child to breathe through the tube, which they may need from months to years.

When the child returns home, a nurse or caretaker stays with them to remove mucus from the tracheostomy tube so it doesn't prevent them from breathing.

However, there isn't an efficient way to identify when the tube is blocked. ME capstone project SmarTrach, an Engineering Innovation in Health and Seattle Children's collaboration, is developing a device that wirelessly monitors a tracheostomy tube and can detect blockage. An alarm sounds when air obstruction reaches intermediate or emergency levels.

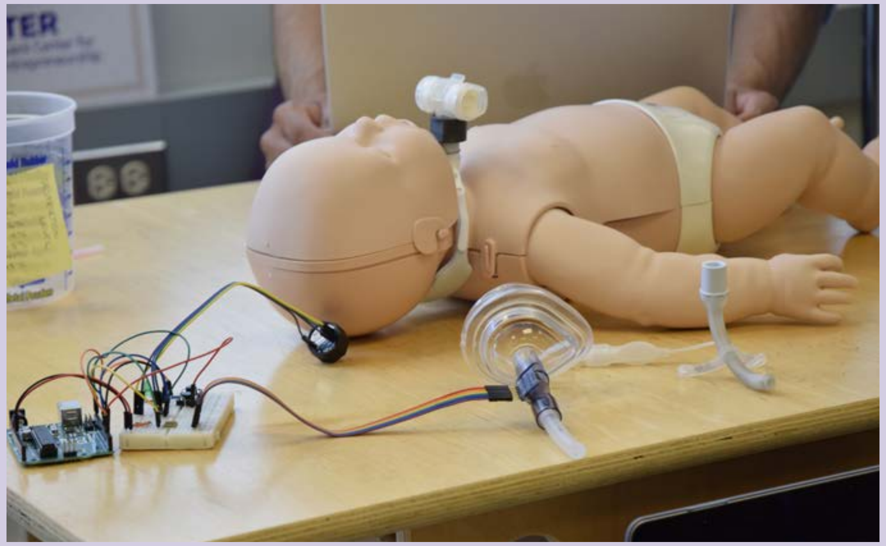
After talking with clinicians, the team decided that measuring airflow using a hot-wire airflow sensor was the most direct way of identifying tube blockage. They attached the sensor externally to the tracheostomy tube.

The students tested the sensor using tubes with artificial levels of obstruction while someone breathed into a connected CPR mask. Using straws containing different materials, they also measured how well the device detected different levels of blockage.

To collect data about how the obstruction changed airflow, the team developed a specialized algorithm. "We didn't have coding experience, so we had to learn how to write code to implement it into our device," says team member Clara Tamura.

In addition to creating a prototype, the students learned about the medical device commercialization process, including understanding FDA regulations, creating a five-year financial plan and estimating manufacturing costs. ■

A team developed a device that monitors a tracheostomy tube and can detect blockage. Photo by Eli Patten



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DEPARTMENT HIGHLIGHTS

Washington Research Foundation Innovation Professor in Clean Energy and ME Professor **Corie L. Cobb** was elected to the Washington State Academy of Sciences.

Albert Kobayashi Professor in Mechanical Engineering **Kat Steele** was promoted to Full Professor.

Supported by the UW + Amazon Science Hub, Associate Professor **Ashis Banerjee** will develop decentralized visual mapping of cluttered scenes using a team of low-cost mobile robots.

Associate Professor **Mehmet Kurt**, who was recently promoted from Assistant Professor, received UW + Amazon Science Hub funding to improve damage level assessment in packages.

The U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy recently selected ME researchers' clean manufacturing projects for funding. Professor **John Kramlich's** project focuses on an innovative approach to manufacturing materials for electric vehicle batteries. Assistant Professor **Aniruddh Vashisth** and Associate Professor **Ashis Banerjee's** project aims to use machine learning and radio frequency fields to weld industry-standard composites.

Teams with ME researchers received spring 2023 CoMotion Innovation Gap Fund awards: Advanced Multi-Organ Regeneration System (AMOR), co-led by Origincell Endowed Professor of Mechanical Engineering **Dayong Gao**; Materialize, led by Professor **Duane Storti**; and Simpl-E-Vac, co-led by Research Professor **Eric Seibel**.

The ThermoTape project, started by ME students under Seibel's mentoring, received funding from the M.J. Murdock Charitable Trust and UW CoMotion to translate their prototype, based on a UW patent, into packaged, sterilized medical tape that can be controlled to be less adhesive at time of removal.