TEXAS A&M UNIVERSITY

J. Mike Walker '66 Department of Mechanical Engineering

A LEGACY OF IMPACT
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WHEELS VS. LEGS
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UNDERSTANDING DROPLET BREAKUP
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MECHANICAL ENGINEERING

SPRING 2021

LEADERS IN ENGINEERING

The J. Mike Walker '66 Department of Mechanical Engineering is one of 15 departments in the Texas A&M University College of Engineering (the biggest college on the Texas A&M campus). Among public institutions in the nation, our undergraduate program is ranked 8th and our graduate program is ranked 9th. Our faculty members are internationally recognized in research areas including: thermal and fluid sciences, materials and manufacturing, mechanics and design, systems and controls, biomechanics and human health, energy and environment, and robotics and mechatronics.

HIGH IMPACT

The department's research encompasses a wealth of mechanical engineering disciplines and houses both state-of-the-art turbomachinery and energy systems laboratories, as well as a national network for manufacturing innovation and connected autonomous safe transportation facilities. Active research efforts within the department are in the areas of combustion, energy systems mechanics, fluid mechanics, heat transfer, polymers, systems and controls, tribology and turbomachinery. Research within the department has resulted in improved processes in various industries, new companies and increased economic activity.

STUDENTS

Students within the department receive a broad education in basic theory courses complemented by laboratory experiences in dynamic systems and controls, design, experimentation, fluid mechanics, heat transfer, manufacturing and materials. Graduates of the department's undergraduate and graduate programs are recruited by manufacturers, health care providers, transportation companies, engineering consulting firms, national laboratories and universities.

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Cover: Faith Leskowitz is testing the Pyrotechnic Art Tool on the Texas A&M University campus.

Letter from the
Department Head

Howdy! Although it has been a difficult year for us all, the J. Mike Walker '66 Department of Mechanical Engineering came together to show the strength of its ingenuity, spirit of service and community.

The department's faculty, students and staff rose to the occasion several times over in working to develop solutions to the many challenges posed by the COVID-19 pandemic. Their work included creating 3D-printed diffusers, manufacturing face shields, researching the use of electron beam irradiation to recycle personal protective equipment and investigating a system of smart building ventilation with National Science Foundation funding.

Our faculty continue to gain success in high-impact research, obtaining major research grants in areas of national importance and receiving recognition from their peers as recipients of prestigious awards. Both Dr. Vinayak Krishnamurthy and Dr. Dion Antao received the National Science Foundation's CAREER Award. Dr. Vinayak's work focuses on developing a new, artificial intelligence-aided approach to geometric modeling and Dr. Antao's research will impact energy conversion and water purification process efficiency. Additionally, Dr. Srikanth Saripalli and Dr. James Hubbard led a winning proposal for a Distributed Autonomous Robotic Experiment and Simulations, funded by the Army Research Laboratories to develop and demonstrate the remote autonomous operation of multiple autonomous vehicles in synthetic and real environments.

Several faculty members in the department were awarded a $1 million grant from the National Science Foundation's Revolutionizing Engineering Departments' program, which will aid in the transformation and growth of our undergraduate curriculum to promote experiential learning while fostering student growth and development. We are committed to leading the way in innovations to advanced pedagogy in engineering education to educate the mechanical engineers of the future.

We continue to grow our faculty to best serve our students and contribute to the department and university's research goals. In 2020, we welcomed three new faculty, Drs. Jacob McFarland, Heng Pan, and Zohaib Hasnain, and have an additional seven faculty slated to join the department this coming academic year. These are Drs. Guillermo Aguilar, Marcia Cooper, Rebecca Friesen, Vanessa Restrepo, Pablo Tarazaga, Jonathan Weaver-Rosen and Robert Ambrose, a National Academy of Engineering member. Their contributions to the field of mechanical engineering will continue to propel our department toward preeminence.

When we welcome students back to campus this fall, we will also be welcoming new department leadership. These eight-and-a-half years have been an amazing journey, and it has been gratifying to see the department grow and transform. We would not be where we are today without the tireless work of our faculty, staff, our dedicated and brilliant students or the support of our generous donors. I believe the department is in excellent shape and that it is time to turn it over to a new department head. Dr. Guillermo Aguilar will be joining us from the University of California at Riverside on July 1. I wholeheartedly welcome Dr. Aguilar to the department and look forward to seeing what the department will continue to accomplish under his leadership.

Andreas A. Polycarpou.

Dr. Andreas A. Polycarpou
Department Head
James J. Cain Chair in Mechanical Engineering

BY THE **NUMBERS**

RANKINGS

#9 Graduate Program Ranked No. 9 (Public) (*U.S. News & World Report*, 2022)

#8 Undergraduate Program Ranked No. 8 (Public) (*U.S. News & World Report*, 2021)

#9 Mechanical Engineering in World Ranking (Academic Ranking of World Universities from ShanghaiRanking, 2019)

ENROLLMENT

(FALL 2020)

1,490 Undergraduates

142 M.S.

79 M.Eng.

258 Ph.D.

ENDOWMENTS

$86.4 MILLION

RESEARCH EXPENDITURES

$28.9 MILLION

FACULTY

63 Tenured/ Tenure Track
- **32** Full Professors
- **21** Associate Professors
- **10** Assistant Professors

11 Texas A&M at Qatar Faculty

21 Emeritus Faculty

18 Academic Professional Track
- **5** Professors of Practice
- **8** Teaching Faculty
- **5** Research Faculty

6 NAE Members

22 Affiliated Faculty

ENDOWED POSITIONS

10 Chairs

12 Professorships

10 Faculty Fellowships

5 Career Development Professorships

Faculty Awards

Dr. N.K. Anand

Professor, James J. Cain '51 Professor III, Executive Associate Dean of Engineering, Regents Professor, Associate Director, Texas A&M Engineering Experiment Station

American Society of Mechanical Engineers — James Harry Potter Gold Medal

Dr. Dion S. Antao

Assistant Professor

National Science Foundation — CAREER Award

American Chemical Society — Petroleum Research Fund Doctoral New Investigator Award

J. Mike Walker '66 Department of Mechanical Engineering — Peggy L. and Charles Brittan '65 Outstanding Undergraduate Teaching Award

Dr. Mark Balas

Professor, Mechanical Engineering and Aerospace Engineering, Leland T. Jordan Professor

J. Mike Walker '66 Department of Mechanical Engineering — Leland T. Jordan Professorship

Dr. Shadi Balawi

Associate Professor of Instruction

Mechanical Engineering Industry Advisory Council — Outstanding Faculty Contribution Award

Dr. Debjyoti Banerjee

Professor, James J. Cain '51 Faculty Fellow I

Texas A&M College of Engineering — Charles W. Crawford Distinguished Award (Engineering Outstanding Contribution Award)

Office of Technology Commercialization, Texas A&M University — Patent and Innovations Award

Dr. Iman Borazjani

Associate Professor

American Society of Mechanical Engineers — Fellow

American Institute of Aeronautics and Astronautics — Senior Member

Dr. Ali Erdemir

Professor, Mechanical Engineering and Materials Science and Engineering, Halliburton Chair in Engineering Professor, Member, National Academy of Engineering

Society of Tribologists and Lubrication Engineers — International Award

Society of Tribologists and Lubrication Engineers — Honorary Member

Japanese Society of Tribologists — Distinguished Tribologist Award

Dr. Swaroop Darbha

Professor, Gulf Oil/Thomas A. Dietz Professor,
J. Mike Walker '66 Department of Mechanical Engineering — Gulf Oil/ Thomas A. Dietz Professorship

Dr. Adolfo Delgado

Associate Professor

J. Mike Walker '66 Department of Mechanical Engineering — James J. Cain '51 Faculty Graduate Teaching Award

Dr. Jaime Grunlan

Professor, Leland T. Jordan '29 Chair Professor

J. Mike Walker '66 Department of Mechanical Engineering — Leland T. Jordan '29 Chair

Dr. Je-Chin Han

Professor, Marcus C. Easterling '30 Chair Professor, University Distinguished Professor

American Society of Mechanical Engineers — Honorary Member

Dr. Yassin A. Hassan

Professor, Nuclear Engineering and Mechanical Engineering, L.F. Peterson '36 Chair II Professor, Member, National Academy of Engineering, Member, The Academy of Medicine, Engineering and Science of Texas

Texas A&M University — University Distinguished Professor

Dr. Harry Hogan

Professor, Acting Senior Associate Dean, Associate Dean for Graduate Programs

American Society for Bone and Mineral Research — Fellow

Dr. James Hubbard Jr.

Professor, Oscar S. Wyatt, Jr. '45 Chair I Professor, Member, National Academy of Engineering

American Institute of Aeronautics and Astronautics — Best Paper Award

United States Board on Army Research and Development — Board Member

Dr. Vinayak Krishnamurthy

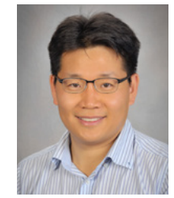
Assistant Professor

National Science Foundation — CAREER Award

Dr. Astrid Layton

Assistant Professor

American Society of Mechanical Engineers 2020 IDETC-CIE Conference, Systems Engineering Information & Knowledge Management Program — Best Paper Award



Dr. ChaBum Lee

Assistant Professor

American Society of Mechanical Engineers — 2020 Blackall Machine Tool and Gage Award

Dr. Richard Malak

Associate Professor, Gulf Oil/Thomas A. Dietz Career Development Professor I

American Society of Mechanical Engineers Design Automation Conference — Ford Best Paper Award

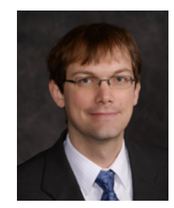
American Society of Mechanical Engineers Design Automation Conference — Paper of Distinction

American Society of Mechanical Engineers SEIKM Conference — R. Fulton Best Paper Award

Dr. Daniel A. McAdams

Professor, Robert H. Fletcher Professor, Associate Department Head of Research and Strategic Initiatives, Mechanical Engineering

American Society of Mechanical Engineers —Design Theory and Methodology Committee Award



Dr. Jacob McFarland

Associate Professor

Pi Tau Sigma — Board of Directors, Vice President At Large

Dr. Tillie McVay

Associate Professor of Instruction

Mechanical Engineering Industry Advisory Council — Outstanding Mentoring Award

Dr. Zheng O'Neill

Associate Professor, J. Mike Walker '66 Career Development Professor

J. Mike Walker '66 Department of Mechanical Engineering — J. Mike Walker '66 Faculty Fellow II

Dr. Eric Petersen

Professor, Nelson-Jackson Chair Professor, Director, Turbomachinery Laboratory

Mercator (Germany) — Mercator Fellow

Combustion Institute — Fellow

American Institute of Aeronautics and Astronautics — Associate Fellow

Dr. Matt Pharr

Assistant Professor, J. Mike Walker '66 Faculty Fellow

National Science Foundation — CAREER Award

Mongague Center for Teaching Excellence — Scholars Award

J. Mike Walker '66 Department *of* Mechanical Engineering — J. Mike Walker '66 Faculty Fellow

Dr. Sivakumar Rathinam

Associate Professor

Office of Naval Research — Senior Summer Faculty Fellowship

Dr. J.N. Reddy

Professor, O'Donnell Foundation Chair IV Professor, Director, Center of Innovation in Mechanics for Design and Manufacturing, University Distinguished Professor, Regents Professor, Member, National Academy of Engineering

Southeastern Conference — SEC Faculty Achievement Award

Laboratory of Arts et Metiers ParisTech at Aix en Provence — Distinguished Visiting Professor

Dr. Luis San Andrés

Professor, Mast-Childs Chair Professor

Global Power and Propulsion Society — Fellow

Dr. Steve Suh

Associate Professor

Nonlinear Dynamics and Complexity Conference — C.S. Hsu Award

Dr. Ya Wang

Associate Professor, Leland T. Jordan Career Development Professor,

International Society for Optics and Photonics — Senior Member

National Science Foundation — Growing Convergence Award

Dr. Choongho Yu

Associate Professor, Sallie and Don Davis '61 Faculty Fellow II

National Academy of Inventors — Senior Member

Staff Awards

Ms. Nicole Latham

Administrative Coordinator I

James J. Cain '51 Staff Excellence Award

Ms. Rebecca Simon

Academic Advisor IV

J. Mike Walker '66 Staff Excellence Award

Ms. Katie Phillips

Senior Business Specialist

James J. Cain '51 Staff Excellence Award

Mr. Michael Douglas

Facilities Manager

J. Mike Walker '66 Staff Excellence Award

Staff Spotlight: **Mitch Wittneben**

The COVID-19 pandemic sparked a revolutionary shift toward remote learning and working. Behind the scenes, skilled technology specialists worked endlessly to ensure this transition was a success. Luckily, Mitch Wittneben, associate director of information technology (IT) in the Texas A&M University College of Engineering, and his team were up for the challenge.

"The IT group was tasked with deploying solutions to provide educational and research services to all of engineering," said Wittneben. "Traditionally, less than 10% of our support was provided in a remote capacity, which shifted to almost 100% remote support. Our team was able to adjust quickly and within three weeks had optimized our operations to support both on-premise and remote interactions."

The contributions Wittneben provided for the department began years before the pandemic. He has supported the mechanical engineering department and the college of engineering for over 30 years.

"I have had the privilege of working alongside outstanding staff, faculty and students," said Wittneben. "I like working with people and providing technical solutions to solve problems. Technology is always changing, and there is always a more efficient way to accomplish a task."

Technical support is only one aspect of his multi-faceted leadership role. One of the most rewarding aspects of his position is sharing knowledge with the next generation.

"Being able to provide professional development and mentorship opportunities to students is the high point of my career," he said. "I recently led a programming team for the invoice management system used by the college's business office. This team was composed of 12 exceptional student programmers who since graduated and have gone on to management positions in development companies such as Apple and Intel."

Wittneben will continue achieving excellence for the department. After his many years of service, every day still presents new opportunities.

"I am extremely fortunate to be a part of Texas A&M Engineering," he said. "I enjoy coming to work each morning, not knowing what the day will bring. I have a plan, but it is always a question as to how long the plan will remain in place."

STRIVING FOR

CONTINUAL IMPROVEMENT

A grant was awarded by the National Science Foundation to induce collaboration among faculty members in the department by encouraging testing and sharing of teaching methods to transform cultural norms.

"The effort of the department is very timely and will significantly enhance the diversity, recruitment and retention efforts of the College of Engineering and serve as a model for other departments and universities," said Dr. M. Katherine Banks, Texas A&M University president and former vice chancellor and dean of engineering.

Research has shown that faculty's views of teaching are often based on individual experience and informal grassroots collaborations. The approach used here is based upon Lean Startup methods focusing on incremental improvements. The project will empower interested faculty to participate in small groups that strive to develop a vision for change.

"This is a unique proposal that aims to change the culture and mindset of faculty and how we teach to the current generation of students," said Dr. Andreas Polycarpou. "In the same way faculty experiment with their research, we want them to follow a similar process for teaching."

The grant will primarily be used to develop training sessions that motivate change, make active classrooms and break down implicit biases.

"Unlike some negative stereotypes for faculty members, most are constantly tweaking courses to benefit students," said Dr. Karan Watson, regents professor in the Department of Electrical and Computer Engineering. "The lack of the convenient environments to explore and share these tweaks with experienced peers results in slow advances of teaching."

By systemically spreading changes more effectively, the department hopes to serve better student learning in research and classroom experiences.

"Students will benefit because they participate and give feedback and will be able to help move courses toward more inclusive and hands-on formats," said Dr. M. Cynthia Hipwell. "We want to develop a shared vision and culture of continuous improvement of teaching."

Others involved with this grant include Dr. Arun Srinivasa and Dr. Mindy Bergman, executive director of Interdisciplinary Critical Studies from the College of Liberal Arts.

FEATURED FACULTY

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Professor; Holdredge/Paul Professor
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A Legacy of Impact

Among the hardships of the last year, the Texas A&M mechanical engineering community lost a valued member of its family in Kathy Lynn '79, who passed away unexpectedly after a hit-and-run collision in Houston on Dec. 17.

Lynn had served as a member of the Mechanical Engineering Industry Advisory Council (IAC) since 2009 and as a member of the IAC executive committee since 2013. She cared deeply about helping train the next generation of engineers and put her passion to work often through her involvement with the department.

Dr. Andreas Polycarpou said among the many ways Lynn contributed to the department over the years included participating in mentoring panels to help guide current students through the challenges presented in today's world, advocating for the implementation of more opportunities for women in engineering, and participating in undergraduate seminars to help prepare students for their upcoming careers.

"Her support of women Aggie engineers was unparalleled," Polycarpou said. "Kathy's passion for training the next generation of engineers, especially women, was unprecedented, and she will be sorely missed."

In addition to her work with the IAC, Lynn also founded the Kathy M. Lynn '79 Scholarship, which has provided support to six female students since its creation in 2015. Since her death, the department community has shown an outpouring of support through gifts to Lynn's scholarship fund.

Brenda Hightower, chair of the department's IAC, said in the years she knew Lynn, she appreciated her dedication to the department and its community.

"I was always impressed by Kathy's heart for serving the Aggie mechanical engineering department, students and former students, especially young women who gained confidence and courage from her leadership," said Hightower. "Kathy modeled kindness, generosity, enthusiasm and willingness to step up and lead the way."

Polycarpou said the department community will miss Lynn's presence, but he hopes her impact will live on through those with whom she interacted.

"These examples of generosity of time and financial support are just a small testament to the strong, kind, compassionate and intelligent woman that Kathy was," said Polycarpou. "I feel proud to have had the opportunity to know her."

ART *MEETS* ENGINEERING

A team of students paired with a pyrotechnic painter, Rosemarie Fiore, to modify a complex tool she will use to make up elements of her art's background.

"The team was drawn to the project because it lies at the intersection of art and engineering," Jon Williamson said, the team's project manager. "Creating a tool that provides a substantial improvement from each of the previous three tool iterations would give the team a sense of accomplishment founded on the importance of art in each member's life."

Fiore is a renowned artist based out of New York known for her firework paintings crafted by custom-made pyrotechnic art tools. Fiore began collaborating with the university in 2018 when she used a tool created by students as part of the painting "Smoke Painting #44," which now hangs in the Zachry Engineering Education Complex.

Williamson's team was assigned this senior capstone design project after a previous team had made significant developments on the tool, which they called the Smoke Paint Tool (SPT). The first team provided a terrific starting point, but identified structural issues that weren't able to be completed due to COVID-19 complications.

The current team, composed of Katy Armitage, Raul Carrillo, Nicholas Harper, Faith Leskowitz and Williamson, took the SPT and sought modifications. Their new design is called the Pyrotechnic Art Tool (PAT).

"Although the PAT differs in many ways from the SPT, it is also based around the chassis and chamber subassemblies," said Williamson. "The current design stemmed from a concept dubbed the 'Platform Tool,' due to the presence of a detachable platform to collect soot and mitigate soot blockages on the bottom plate of the tool."

The tool works as a pressure vessel. By lighting smoke canisters and placing them in the tool, the canisters are able to produce large amounts of smoke. The smoke moves into the dispersion chamber, causing a rise in pressure in the chamber. The difference in pressure between the chamber and the environment draws smoke through holes in the tool's bottom plate and onto canvas, creating varying marks as the artist manipulates the tool.

The team of students developed the tool to make up elements of Fiore's art pieces.

Smoke moves through the holes and onto the canvas, creating varying marks.

Wheels vs. legs:

TRANSFORMING ROBOTS

A team of researchers is creating mobile robots for military applications that can determine, with or without human intervention, whether wheels or legs are more suitable to travel across terrains. The Defense Advanced Research Projects Agency (DARPA) has partnered with Dr. Kiju Lee to enhance these robots' ability to self-sufficiently travel through urban military environments.

The DARPA OFFensive Swarm-Enabled Tactics (OFFSET) program awarded Lee and a team of graduate students another opportunity after her prior successful accomplishments on developing a mixed-reality swarm simulator with embedded consensus-based decision making for adaptive human-swarm teaming as part of the OFFSET Sprint-3. This project was showcased at OFFSET's third field experiment (FX3).

"I have recently been awarded a new DARPA contract to join the OFFSET Sprint-5 effort focusing on enhancements to (the robot's) physical testbeds," Lee said. "Through this new project, I will develop unmanned ground vehicles with agile and versatile locomotive capabilities for urban military operations."

Lee and her team are developing an adaptable Wheel-and-Leg Transformable Robot (α-WaLTR) that can traverse over varying surfaces, including staircases, more efficiently. The α-WaLTR will move with wheels or legs depending on their immediate need and will be able to decide for itself which to use.

"Legged locomotion is more versatile, but suffers from inherent structural, mechanical and control complexities," Lee said. "The proposed testbed will be equipped with novel wheel/leg transformable mechanisms, which can switch between the two locomotion modes actively adapting to its environment, but without needing any additional actuator.

"While the current focus is on defense and other military applications, these types of adaptable mobile robots can be applied to many other areas, such as space, domestic service, surveillance and agriculture," said Lee.

The OFFSET Sprint-5 effort is led by Lee along with the help of five graduate students and one undergraduate student — Chuanqi Zheng, Siddharth Sane, Vishnu Kalyanram, Kangneoung Lee, Sohil Parsana and Jenna Horn.

FEATURED FACULTY
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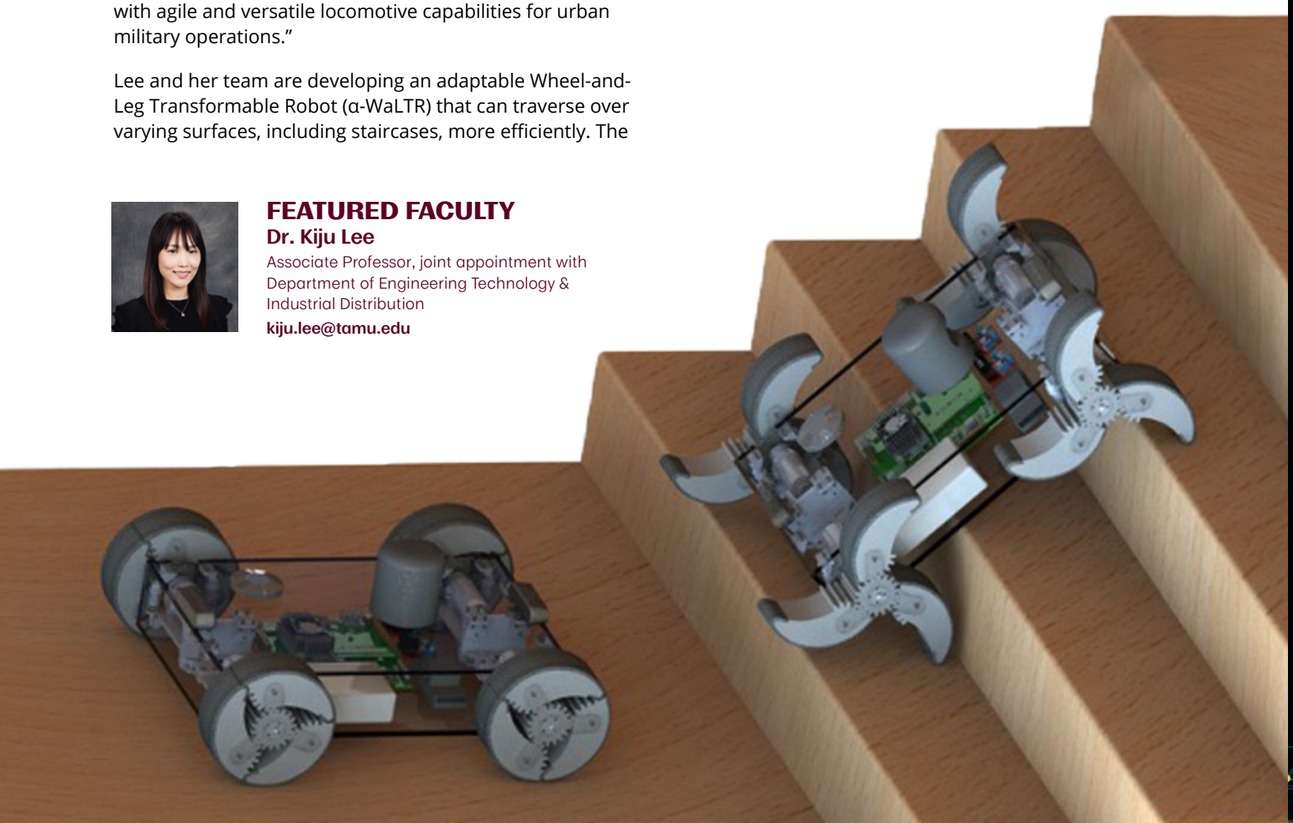

Pursuing Autonomous Modeling

Dr. Zohaib Hasnain's research shows that data-driven techniques used in autonomous systems hold the potential to solve complex modeling problems more accurately and efficiently. Applying high-functioning artificial intelligence to physics-based processes, he aims to "automate" modeling, reducing the time it takes to produce solutions and cutting production costs.

Hasnain realized the delay in projects due to modeling efforts. While conducting traditional modeling processes, researchers must create various models and file through individual models, which takes an extended period of time to produce answers. This results in hefty costs computationally, and in human labor for verification.

"I always thought that there was work to be cut out because there are autonomous systems and machines that seemed capable of handling the bottleneck that is modeling," Hasnain said. "My research is a first step in understanding how and when data-driven techniques are beneficial, with the ultimate goal of taking a process that consumes months or weeks to solve, and producing a solution in hours or days."

Hasnain, accompanied by Dr. Vinayak R. Krishnamurthy, assistant professor, and graduate research assistant Kaustubh Tangsali, conducted a study to understand how commonly used machine-learning architectures such as convolutional neural networks (CNN) and physics informed neural networks (PINN) fare when applied to the problem of fluidic prediction. Their research found that both CNN and PINN have the potential to optimize modeling processes if targeting very specific aspects of the solution process.

The researchers published their findings in the *Journal of Mechanical Design.* Their article, "Generalizability of Convolutional Encoder-Decoder Networks for Aerodynamic Flow-field Prediction Across Geometric and Physical-Fluidic Variations," focuses on understanding dimensional tools that have the potential of replacing modeling tools that are the current industry standard.

Hasnain hopes to build an autonomous infrastructure that pulls from a collection of data to produce modeling solutions through hybrid machine-learning architectures. Eventually, he plans to share this infrastructure for widespread, free usage.

"I would like this infrastructure to be a community initiative that's offered free to everyone," Hasnain said. "Perhaps more importantly, because it can produce near on-demand solutions as opposed to the current modeling state-of-the-art."

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For the Love of **Rotordynamics**

Marie Kasprzyk's favorite book, "Turbomachinery Rotordynamics with Case Studies," was written by Dr. Dara W. Childs. Childs '68 is an emeritus professor and the previous director of the Turbomachinery Laboratory from 1984 to 2018. Inspired by his work, Kasprzyk is carving her path as a graduate research assistant in this lab.

"Some of the best rotordynamicists come from the Turbomachinery Laboratory," said Kasprzyk. "Being able to work here is an honor. You learn from the best of the best, especially since Dr. Childs really made turbomachinery what it is today."

Rotordynamics is the study of mechanics relating to rotating machinery, such as jet engines or centrifugal compressors. Kasprzyk became intrigued by this topic the first time she saw a steam turbine.

"They were amazing at first sight," said Kasprzyk. "I took mechanical vibrations at the University of Central Florida (UCF), and I enjoyed the topic. That's when I began heading toward turbomachinery."

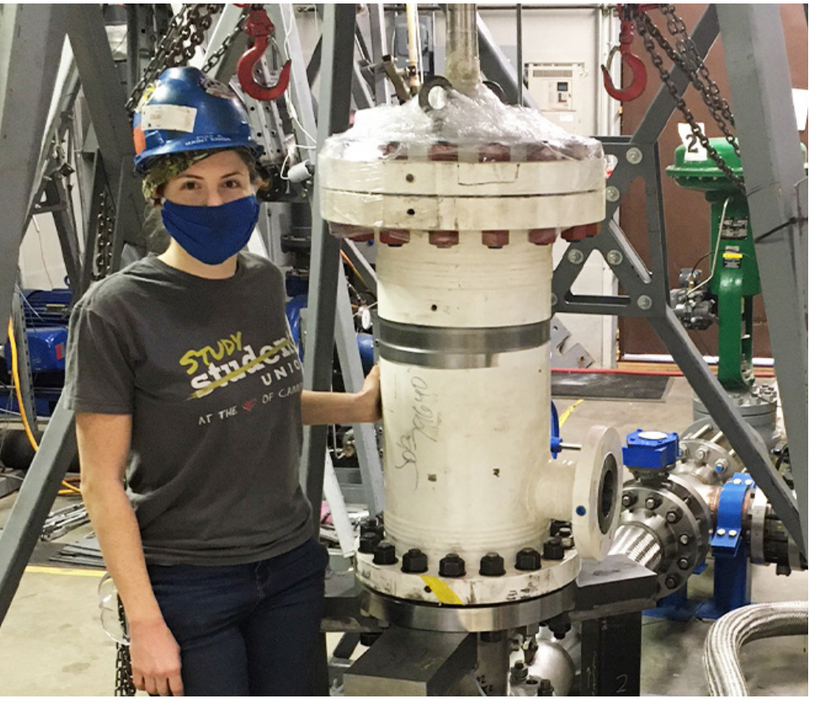
Kasprzyk graduated with her bachelor's in mechanical engineering from UCF in 2013 and began working as a reliability engineer at a chemical plant. Kasprzyk continued, earning her master's degree in 2017 while working full-time. During her senior year at UCF, Dr. Suhada Jayasuriya recommended Texas A&M University to Kasprzyk due to her interest in turbomachinery and the lab's excellent opportunities.

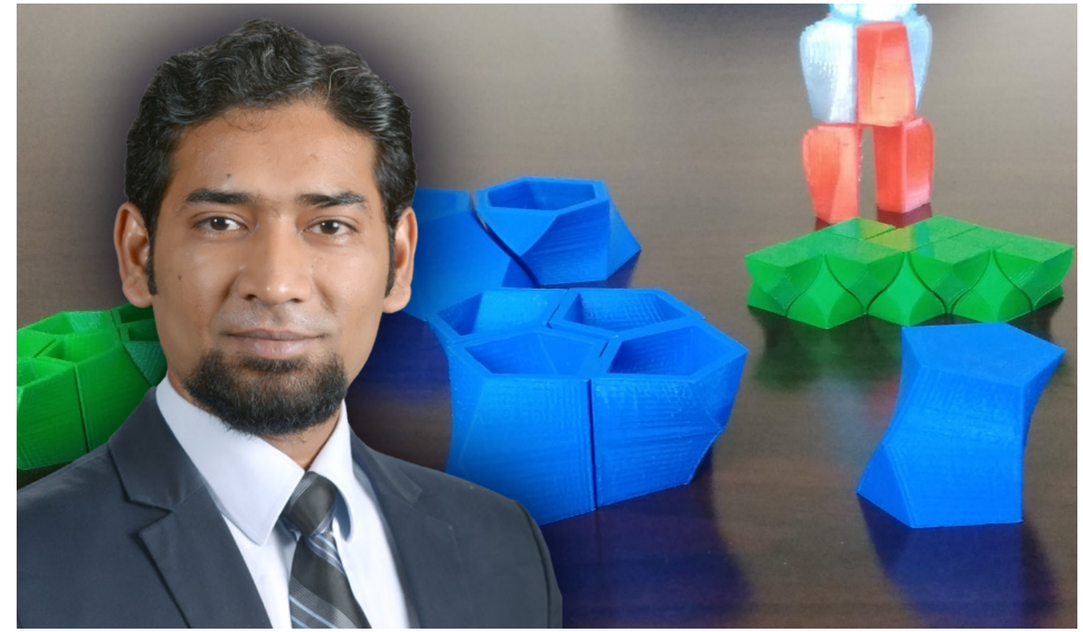
Having brought her passion to Texas A&M, Kasprzyk's expectations were exceeded by the turbomachinery program.

"I feel like I have received the best education I could have asked for in rotordynamics," said Kasprzyk. "Texas A&M offers all the resources possible. The department supports you, and they hire the best professors that provide wonderful research opportunities."

Dr. Adolfo Delgado, an associate professor, is Kasprzyk's advisor. According to Delgado, Kasprzyk's attitude and experience have significantly impacted the lab and those around her.

"She is a role model to many students at the Turbomachinery Laboratory," said Delgado. "She upholds the highest standards of safety and professionalism. She is an outstanding mechanical engineer and the best designer in my research group. Marie is the go-to person for any questions regarding the design, modeling, installation and commissioning of rotordynamic test rigs and rotating equipment."





3D Patterns Improving Design

Dr. Vinayak Krishnamurthy received the 2021 National Science Foundation's Faculty Early Career Development (CAREER) Award. The CAREER Award is designed to allow junior faculty to pursue cutting-edge research and advance excellence in education.

"The award will allow me to continue my efforts on building a foundation for my long-term goal — to create the next generation of design tools that augment the designers' cognitive ability for creative problem-solving," said Krishnamurthy.

With the help of this award, he is developing a new approach to geometric modeling that could have a wide breadth of applications, ranging from prosthetic devices to automotive parts.

His research introduces a geometric modeling paradigm, called partitive solid geometry, which can enable the intuitive and interactive design of complex 2D and 3D patterns.

Using this model, designers can create more robust materials or safer products that may improve the average person's quality of life.

"Imagine a computer tool where a designer could sketch out a shape to design a complex 3D jigsaw puzzle that has special mechanical or optical properties," he said. "The research specifically focuses on developing the mathematical principles, and subsequently new algorithms and interactive software workflows to enable such design."

In addition to its commercial applications, Krishnamurthy sees value in the shapes for the amateur or student — equipping them with the tools necessary to explore creative solutions.

"With maker culture on a steep rise, more people are interested in designing their own products," he said. "It is now possible to buy a 3D printer or a laser cutter and create small businesses on a budget. Making complex geometric modeling accessible is key to facilitating disruptive innovations in many engineering disciplines."

The award will help bring these design tools to K-12 students through a learning mechanism he calls "design-prototype-play." Using these tools, students could generate complex structures and use 3D printing to prototype them as puzzles to discover the basic principles of geometry.

Krishnamurthy is creating a comprehensive plan for implementing these tools that will include internships for undergraduate students, a new graduate-level course on generative design, partnerships with outreach programs and a free web-based modeling tool available to the public.

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Understanding **Droplet Breakup**

By seeking to understand how tiny droplets behave when subjected to high pressure and temperatures, Texas A&M University researchers could contribute to the development of more efficient engines for propulsion and energy production applications.

Their project, titled "Droplet Breakup and Vaporization Effects in High-Speed Liquid-Fueled Combustion," investigates how liquid droplets break up, vaporize and react in detonation waves, which may lead to better engine technologies.

"One day we may be able to use liquid-fueled detonation waves to power our commercial and military aircraft or to provide more efficient electric power generation," said Dr. Jacob McFarland. "Understanding how droplets break up can benefit us in other areas as well, such as delivering aerosolized medicines more efficiently, developing safer methods for destroying chemical or biological weapons, mitigating the spread of diseases through airborne droplets and developing more efficient power generation and refrigeration technologies."

McFarland is leading the research effort, for which he was awarded the 2020 Young Investigator Award from the United States Office of Naval Research.

Funding for the project began Sept. 1 and is scheduled to continue for the three-year duration of the award.

While the rotating detonation engine — most commonly used in the propulsion of aircraft and rockets — is the primary focus of the research, McFarland said advances in the technology could also benefit more conventional liquid-fueled engines as well as supersonic-combustion ramjet engines.

McFarland said the award is a great honor and opportunity for a young faculty member like himself, and that he is excited for the lifelong expertise it will help him build in this subject area.

"The project will support the development of a new liquid-fueled detonation tube facility and to purchase new instrumentation to allow us to image droplet breakup under these conditions for the first time," McFarland said. "It will also support the studies of a post-doctoral researcher and undergraduate researchers to train in this field of research."

FEATURED FACULTY
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Masks Made Easy

In response to the early face mask shortage in 2020, a team of students bonded together to create the EASYMASK. Funded by the National Science Foundation's (NSF) I-Corps Site program, it was designed as a superior alternative to homemade masks that provides a safer user experience.

"To alleviate the demand for medical-grade face masks, conserve N95 masks (surgical masks) for medical workers and provide a dependable, reusable and inexpensive face mask to the general population, our team designed the EASYMASK," Noble Gutierrez said. "The EASYMASK concept provides a better seal and protection than disposable and homemade masks and utilizes common materials found at home such as filters."

Gutierrez is a student in the mechanical engineering department and a member of the team who created the EASYMASK during the Aggies Against COVID-19 Virtual Competition. His team, which consisted of half engineering students and half public health students, included Ian Suarez, Veronica Perez, Sterling LaBoo, Cecilia Torres and Thomas Goodwin.

The EASYMASK is a mask frame that combines comfort with sustainability, allowing users to interchange the mask filters with typical household items.

"Common household fabrics can be as effective as surgical masks in the filtration of particles depending on the combination and layering of materials," Gutierrez said. "The EASYMASK's simple frame allows the user to insert their own filters made from fabrics that can be easily, frequently and inexpensively replaced. The mask eliminates the compulsory need for users to regularly adjust their masks, reducing the risk of contamination."

The product's success provided eligibility into the NSF I-Corps Site program. Through this program, students receive guidance and funding to take their products from conceptualization to the market. The team will continue working on their product with the NSF I-Corps Site program to develop their prototype and aid in the fight against COVID-19.

Innovation & Adaptation

In the first few months of the U.S. response to the COVID-19 pandemic, a team of nine students created the Coro-NO UV-Clave, earning a top 10 spot in the Aggies Against COVID-19 Virtual Competition. Marianela Cintrón and John Karako, students in the mechanical engineering department, were part of this effort. After realizing that similar technology had already been produced, the NSF I-Corps Site program provided an opportunity for the team's creation to evolve through adaptations to their original product. This resulted in the team's development of Sterilight in the summer of 2020.

"I thought this was a great way to get involved and make a difference with everything that was happening," said Cintrón. "I pulled a group of friends together who were interested and we created a solution to the mask shortage."

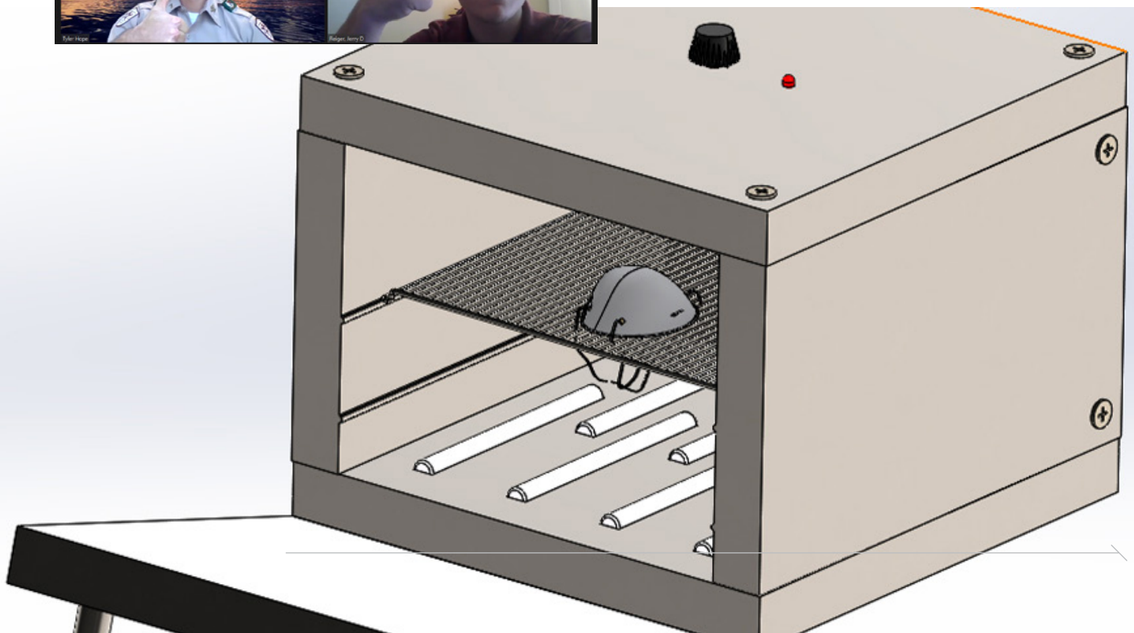
The Coro-No UV-Clave is a light chamber that resembles an oven. Placing an object in the chamber, such as a mask, quickly and efficiently sanitizes that object by using UV-C lighting.

"By the time we finished the design and presented it during the competition, there were tons of products like this already on the market," said Karako. "(NSF I-Corps Site) reached out after we placed in the top 10, offering to fund changes to the project, and four of us decided to continue working on it."

The team of four now includes Karako, Cintrón, Tyler Hope and Jerry Reiger.

Their revised product was called Sterilight. According to Karako, the primary change from their original invention was stopping the use of UV-C in exchange for another light source, far UV-C. This change eliminates potentially harmful radiation that is associated with UV-C lights. As Cintrón also pointed out, far UV-C has a broader range of materials it can sanitize.

Their goal was to see Sterilight being used in areas where frequent cleaning is required. This can range from school districts and laboratories, to grocery stores and malls. Their mission was to reduce the fear of transmission through using community objects such as card readers or classroom necessities.



Improving Polymer Performance

Although widely used, polymers bring with them challenges often determined by the processing conditions in which they are made. With the ability to understand the factors of how these materials are influenced in their creation, Dr. Anastasia Muliana and her team could unlock great control and customization of polymer performance and durability.

Polymers — materials consisting of long molecular networks, also known as macromolecular structures — are used in daily life and have wide-ranging applications from the automotive industry, aerospace and infrastructure to packaging, agriculture and biomedicine.

A major challenge, however, is that often the same types of polymers can show significant variations in the properties they exhibit — an effect caused by differing processing conditions that can alter the chemical and physical properties of cured polymers.

"Investigating the link between processing, structure, property and stimuli on the time-dependent responses of polymers is necessary to design and process polymers with the desired performance for their applications and also to provide a long-term solution for recyclability or biodegradation," said Muliana.

The team's focus has centered on better understanding the time-dependent mechanical responses of polymers when exposed to various environmental conditions.

The new approach to understanding the influence of processing conditions on the polymer links the processing, structure, property and stimuli information to the time-dependent responses of the polymers, allowing the researchers to further consider physical mechanisms and relevant macromolecular information.

"Polymer processing and characterization of polymer properties are usually done separately and independently, where investigations on short- and long-term responses of polymers are often performed without incorporating knowledge of processing histories nor information on basic chemical properties," Muliana said. "For the same type of polymers, large variations in the properties are often found in literature, which makes it challenging to use this information for designing with polymers, and often time it is necessary to experimentally characterize the properties of a polymer after each processing condition."

The benefits of Muliana's approach to discovering the influence of processing conditions on the properties of polymers could be three-fold:

1. To permit for the design of polymers with desired life performance
2. To reduce the number of experimental characterizations required to determine the polymer properties
3. To support the future digital twin concept in polymer processing, predicting life performance of polymers during their service and designing for after-life of polymers

FEATURED FACULTY
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A Journey to *Mechanical Engineering*

When it comes to giving back, it's just what Aggies do. For Jay Stafford, a graduate of the mechanical engineering department, supporting the university that provided him with the education to launch a successful career was not a big deal — it was simply the right thing to do.

Like Stafford, however, not all who join the department had a straight path to mechanical engineering. The Houston native first came to Texas A&M University in 1943 to study in the College of Agriculture, and his journey included many twists and turns along the way. As a sophomore, Stafford was drafted into the U.S. Navy where he served for nearly two years before returning to complete his agriculture degree at Texas A&M. But when he graduated in 1948, his path diverged from those of his classmates. While many of his peers set off to serve as county agents, he knew that path wasn't for him.

"I'm not a public speaker, so that didn't fit me at all," Stafford said. "So I kind of drifted off into something else."

Something else, it turned out, was geophysical work — a decision that would take him around the world.

By December 1948, he was living and working in Saudi Arabia. Stafford would stay there for five years — a time he remembers fondly for frequent summer vacations in Europe — before getting married and moving first to Australia, then Guatemala.

In 1958, Stafford returned to Texas A&M determined to forge a new path for himself. He decided to pursue a new bachelor's degree, having felt drawn toward mechanical engineering work during his career in geophysics.

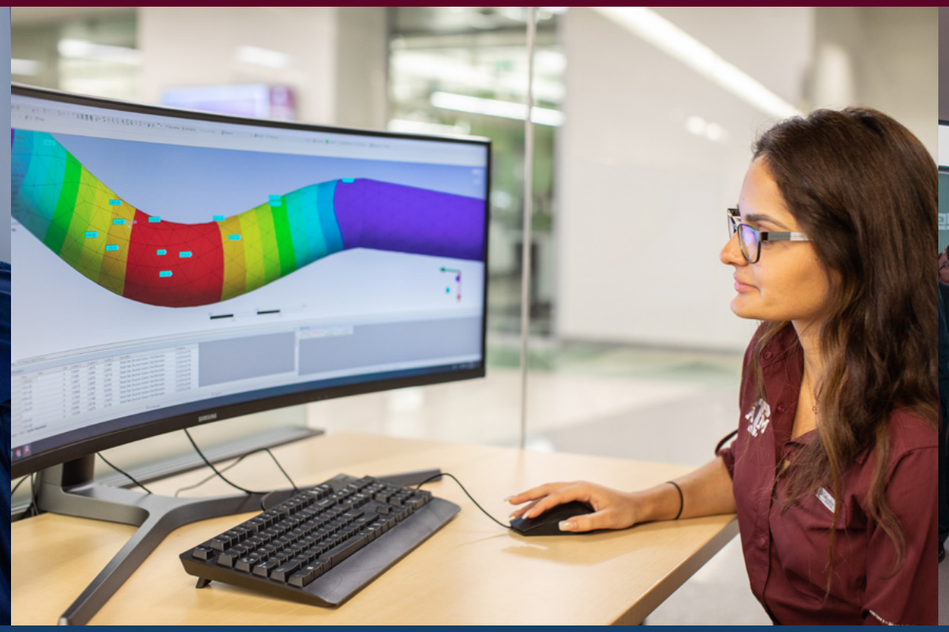
> "Aggies stick **together** and that's what I'm trying to do."

After graduating in 1963, Stafford went to work for Conoco, designing seismic vibrators for their geophysical explorations equipment. He would remain there until 1985. During this time, Stafford experienced professional success in his work developing better, more efficient seismic vibrators to support Conoco's explorations department, holding several patents in his name for the parts he created. At the same time, he also experienced personal loss with the death of his wife in 1975.

In 1978 Stafford remarried, and by 1988 he had retired. Now living in Oklahoma, Stafford said he wanted to give back to the department to pay forward the education he received in mechanical engineering. He and his wife Millie have funded an undergraduate scholarship, established in 2006, which supported 14 students in 2020.

They have plans for several additional avenues to support the department, including three professorships, three faculty fellowships and two graduate fellowships. In looking at the impact their scholarship has already had, Stafford said he hopes it will continue to help students to stay in school and to achieve their goals, whatever they may be.

"There are many students that need help and I'm able to do it at this point," Stafford said. "It's the right thing to do. Aggies stick together and that's what I'm trying to do. There are many more that do the same thing. I just do what I can do."


BRIDGING THE GAP

Inspired by her own experience with a senior capstone design project, Dr. Joanna Tsenn now seeks to help undergraduate students bridge the gap between the classroom and industry through projects of their own.

"Senior design was one of my favorite classes when I was a student — in fact, it is why I chose to do my Ph.D. in mechanical engineering design," Tsenn said.

Tsenn serves as both the projects coordinator and an instructor for the mechanical engineering department's senior capstone design program — a role in which she finds great pride and fulfillment. Using her passion for the course material, helping students and problem-solving, alongside her organizational strengths, Tsenn said the department's senior design program is a uniquely impactful experience.

"I think our capstone program is one of the best," Tsenn said. "We have larger teams and they focus on the same project for two semesters, so they are able to tackle bigger projects. With the Fischer Engineering Design Center, access to departmental equipment and tools, and faculty support, the teams are able to accomplish incredible work over the course of their projects."

The two-semester senior capstone design program provides students with open-ended design projects — many times supported by industry sponsors — that require students to apply their knowledge by completing a needs analysis, identifying requirements, generating concepts, selecting a solution and validating their solution.

Tsenn said in addition to learning to apply their engineering education to real-world applications through a hands-on design process, another primary focus of the program is to help students develop their professional skills, including communication, teamwork, project management, critical thinking, decision making, creativity and adaptability.

She said seeing students take all of these lessons and use them to complete their projects is one of her favorite things about the program.

"I want the teams to take the lead and take ownership of their projects," Tsenn said. "I can tell that we have been successful as instructors when the teams no longer need us to guide them. It is a great feeling to receive a team update where they identified a problem, developed solutions and figured out how to get back on track all on their own."

FEATURED FACULTY

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Walker Eminent Lecture Series

The Walker Eminent Lecture Series was established by Dr. J. Mike Walker '66 in 2018. With this endowment, the J. Mike Walker '66 Department of Mechanical Engineering invites nationally recognized scholars to Texas A&M University to conduct lectures as part of the graduate department seminar class.

Reaction-Diffusion Driven Pattern Formation in Thermosetting Polymers

April 14, 2021

Reaction-diffusion processes are versatile, yet underexplored methods for manufacturing that provide unique opportunities to control the spatial properties of materials, achieving order through broken symmetry. The mathematical formalism and derivation of equations coupling reaction and diffusion were presented in the seminal paper by Alan Turing [Phil. Trans. R. Soc. Lond. B 237, 37,1952], which describes how random fluctuations can drive the emergence of pattern and structure from initial uniformity. Inspired by reaction-diffusion systems in nature, this talk will describe a new processing strategy predicated on the exploitation of an advancing polymerization front sustained through coupled reaction and thermal diffusion. The system uses the exothermic release of energy to provide a positive feedback to the reaction. In turn, this stimulates further exothermic energy release and a self-propagating reaction "front" that rapidly moves through the material – a process called frontal polymerization. We recently reported the frontal ring-opening metathesis polymerization of dicyclopentadiene that exhibits the high energy density, high reactivity, relatively long pot life, and how viscosity required for the synthesis of high-performance thermosetting polymers and composites [Robertson et al., Nature, 557 (2018)]. This talk will describe several novel methods to control thermal transport in this system, giving rise to symmetry breaking events that enable complex, emergent pattern formation and control over growth, topology, and shape.

Dr. Nancy R. Sottos

Department Head
CAS Professor and Swanlund Chair
Department of Materials Science and Engineering
University of Illinois at Urbana-Champaign

Dr. Nancy Sottos holds the Maybelle Leland Swanlund Endowed Chair and is Head of the Department of Materials Science and Engineering at the University of Illinois Urbana Champaign. She leads the Autonomous Materials Systems group at the Beckman Institute for Advanced Science and Technology and is director of the University of Illinois spoke of the BP International Center for Advanced Materials. Sottos is also a co-founder of Autonomous Materials Inc. Inspired by autonomous function in biological systems, the Sottos group develops polymers and composites capable of self-healing and regeneration, self-reporting, and self-protection to improve reliability and extend material lifetime. Her current research interests focus on new bioinspired methods to manufacture these complex materials. Sottos' research and teaching awards include the Office of Naval Research Young Investigator Award, Scientific American's SciAm 50 Award, the Hetényi Best Paper Award in Experimental Mechanics, the M.M. Frocht and B.J. Lazan Awards from the Society for Experimental Mechanics, the Daniel Drucker Eminent Faculty Award, the Institution of Chemical Engineers Global Research Award, and the Society of Engineering Science Medal. She is a member of the National Academy of Engineering, and a fellow of the Society for Experimental Mechanics and the Society for Engineering Science.

Fowler Distinguished Lecture Series

The Fowler Distinguished Lecture Series was established by Donald Fowler '66 and Dr. Joe Fowler '68 in 1999. With this endowment, the J. Mike Walker '66 Department of Mechanical Engineering invites nationally recognized scholars to Texas A&M University to conduct lectures as part of the graduate department seminar class.

Energy and Climate: The Defining Issue of the 21st Century

March 23, 2021

Energy use is the foundation of all modern economies and is well correlated to the human development index. Over the 19th and 20th centuries, research in energy conversion and use laid the foundations for modern science, such as the laws of thermodynamics, electromagnetism and others. Because 80% of the global energy today comes from fossil fuels, the emission of CO2 and other greenhouse gases (GHGs) is producing global warming at an alarming rate. While the global average temperature rise is 1.2 C compared to pre-industrial levels, the world is facing climate-induced weather extremes, which are becoming more frequent, more intense and longer lasting. These extreme events are appearing at locations that are as yet unpredictable. Recent satellite observations suggest some worrisome trends about the dynamics of the Earth's carbon cycle, which we don't fully understand. Part of this lecture will focus on this issue that is critical for adaptation and resilience.

Dr. Arun Majumdar

Director, Precourt Institute for Energy
Jay Precourt Professor
Professor, Mechanical Engineering and Materials Science Engineering
Stanford University

Dr. Arun Majumdar is the Jay Precourt Provostial Chair Professor at Stanford University and a faculty member of the Department of Mechanical Engineering. From 2009 to 2012 Majumdar served as the founding director of ARPA-E and from March 2011 to June 2012 as the acting under secretary of energy. After leaving Washington, Majumdar was the vice president for energy at Google. Majumdar is a member of the National Academy of Sciences, National Academy of Engineering and the American Academy of Arts and Sciences. He also served as the vice chairman of the advisory board to the U.S. Secretary of Energy, Dr. Ernest Moniz, was a science envoy for the U.S. Department of State, and serves on the advisory board of numerous energy businesses and nonprofits. Majumdar received his B.S. in mechanical engineering in 1985 from the Indian Institute of Technology, Bombay, and his Ph.D. from the University of California, Berkeley in 1989.

Turbomachinery Distinguished Lecture Series

The Turbomachinery Distinguished Lecture Series was established in 2014. With this endowment, the J. Mike Walker '66 Department of Mechanical Engineering invites prominent speakers in the area of turbomachinery to present lectures of interest to our students and faculty.

Control of Instabilities in Transverse Jets in Turbomachinery Systems

February 3, 2021

Complex flow phenomena are widely present in systems involving energy generation and propulsion, and control of such fundamental phenomena in gas turbine engine flowfields is key to the development of efficient, robust systems. This talk will describe research at University of California, Los Angelos on flow instabilities and their control, in the spirit of this fundamental approach, with a focus on the canonical gaseous jet in crossflow (JICF) or transverse jet. New insights into JICF shear layer stability characteristics have created the potential for tailored flow control which can alter jet dynamics, molecular mixing and other important features of the jet flow. Quantification and interrogation of the flowfield involves use of acetone planar laser-induced fluorescence imaging and simultaneous stereo particle image velocimetry, as well as hot wire anemometry. Transitions in shear layer instabilities from convective to absolute instability are observed to depend on specific flow conditions, with attendant alterations in jet structure and symmetry that can have a significant effect on mixing metrics. These fundamental stability characteristics require alternative methods for jet control, depending on the flow regime, which can optimize performance of the jet in various applications.

Dr. Ann R. Karagozian

Mechanical & Aerospace Engineering
University of California, Los Angeles

Dr. Ann Karagozian is a Distinguished Professor in the Department of Mechanical and Aerospace Engineering at UCLA. Her research interests lie in fluid mechanics and combustion as applied to improved energy efficiency, reduced emissions, and advanced air breathing and rocket propulsion systems. Karagozian is a current member of the Air Force Scientific Advisory Board, (SAB) having served previously as SAB vice chair and twice receiving the Air Force Decoration for Exceptional Civilian Service. She is a member of the National Academy of Engineering and is a fellow of American Institute of Aeronautics and Astronautics, American Physical Society, and American Society of Mechanical Engineers. She received her B.S. in engineering from UCLA and her M.S. and Ph.D. in mechanical engineering from the California Institute of Technology. She is a member of the board of trustees of the Institute for Defense Analyses.

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The Kathy M. Lynn '79 Scholarship was endowed by Kathy Lynn in 2015 to provide scholarships for juniors who are members of the Society of Women Engineers and have maintained a 3.5 GPA or higher.

Mechanical Engineering Excellence Fund

These funds provide general support to the department for a variety of endeavors that include professional development for faculty, staff and students; student organization support; development activities; award recognition and more.

Student Development Fund

To provide a truly impactful learning experience to our students, we must be able to venture outside of the classroom. In order to provide meaningful content, the student development fund can be utilized for study abroad opportunities, emergency scholarships, bring in esteemed guest lecturers or public speakers, and ensure that student groups have financial means to attend national conferences and competitions.

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The Mechanical Engineering Advancement/Industry Advisory Council Fund provides support to recruit and retain the best faculty and students through faculty fellowships, endowed undergraduate scholarships, department head strategic initiatives and faculty and staff recognition and support.

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J. Mike Walker ’66 Department of Mechanical Engineering

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