MechE CONNECTS

Spring 2025

FOUNDATIONS

MechE CONNECTS

Spring 2025 | meche.mit.edu

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Senior Dana Barker is the proud new owner of Rick and Morty’s spaceship, the centerpiece from the Spring 2024 2.007 competition board! The spaceship was a giveaway at the Fall 2024 MechE Block Party. Credit: Tony Pulsone

MIT MECHE

About MechE

The MIT Department of Mechanical Engineering – MechE – advances the design, fundamental principles, and realization of physical systems with mechanical engineering at their core. Our research and education programs embody MIT’s motto “mind and hand,” as well as “heart,” combining theory and hands-on learning with a commitment to make the world a better place. By uniting the core areas of MechE with emerging frontiers, we discover new knowledge, create innovative technologies, and train future leaders who help address the biggest challenges facing our society.

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Cover:
Foundational moments in MIT MechE history.

Credit: Wing Ngan

Have updates or news to share with the MechE Community? Would you like to share an idea for a future issue of *MechE Connects*?

Email us at mecomms@mit.edu

> **“We explore MechE’s history, our Foundations, and we celebrate people, spaces, and ideas that have shaped our department and field through the years.”**

Dear MechE Alumni, Students, Faculty, Staff, and Friends,

From MIT’s earliest days, mechanical engineers have tackled challenges of the times — advancing the fundamentals of the discipline, inventing breakthrough technologies, and bringing innovations to scale.

This past year, we had occasion to celebrate two milestones in MechE history. 150 years ago, during the 1873-74 academic year, MechE’s first lab opened its doors. And, around this same time, we officially became known as Course 2, after originally being designated as Course 1! We celebrated these milestones with events this spring, “2.150: Celebrating the history and future of Mechanical Engineering at MIT.” Alongside reflections on MechE’s history, we held our annual 2.007 robotics competition and de Florez competition, and welcomed distinguished guests alongside alumni for lectures, lab tours, and other activities. As I watched our students compete in 2.007, I reflected on how far we’ve come since the early days of 2.70 (the precursor to 2.007) as well as its beginnings in the early 1970s, and on the similarity of the pedagogy and principles now and then.

In this issue of *MechE Connects* we explore MechE’s history, our *Foundations*, and celebrate people, spaces, and ideas that have shaped our department and field through the years. Among the feature stories, you’ll read about MechE’s first lab, the Steam Lab. You’ll also read about the legacy of Professor Woodie Flowers and his tremendous influence on engineering education at MIT and beyond. And, we invite you to revisit the 2.150 celebration.

In our alumni spotlight, you’ll meet Ravi Patil, ’93, SM ’95, an IT executive and the host and creator of a podcast called *INSTITRVE – True stories about MIT*. In our class spotlight we invite you to learn about 2.678 (Electronics for Mechanical Systems) and 2.737 (Mechatronics).

MechE’s early years brought life to ideas and technologies that still have an influence on the world. We hope you enjoy this issue, and the connections past and present.

With best regards,

John

John Hart
Class of 1922 Professor
Department Head

Full Steam Ahead

MechE's first laboratory set the stage for the department's legacy in thermal sciences, energy conversion and a host of other innovation happening today

By Anne Wilson, with content adapted from the writings of "Mr. Mooney" at MIT in the late 1940s.

In 1873, Channing Whitaker, SB 1869, professor and head of mechanical engineering courses from 1875 to 1883, redirected the Department of Mechanical Engineering's educational emphasis toward empirical studies, proposing the use of in-house teaching laboratories and increased excursions to industrial and civil sites. In 1874, mechanical engineering's first laboratory opened. The lab was intended "for direct application of current methodology to engineering problems."

"That first lab was, indeed, the Steam Lab," says John Hart, the Class of 1922 Professor and Head of the Department of Mechanical Engineering. "It laid the foundation for thermal engineering in MechE, catalyzing a legacy of fundamental discoveries and pivotal technologies in thermal sciences and energy conversion that continues today."

The Steam Lab was built with a gift from a local businessman, Mr. George Basil Dixwell. An account of this early history written in the 1940s by

A photo from the MIT archives labeled "Steam Engine Test" and "MIT Steam and Hydraulic Lab" date unknown. Credit: MIT Museum

an author identified as Mr. Mooney notes that Dixwell had studied the steam engine and wanted independent experiments to test his conclusions regarding the value of superheated steam in preventing cylinder condensation.

"This was at that time a subject of technical dispute and of great economic importance," writes Mooney. "Subsequent to the completion of Mr. Dixwell's tests, many other tests were run for instructional and research purposes; the effect of the governing method upon the economy, and the effect of higher steam pressure upon the economy were among the matters investigated."

The 1876 MIT Course Catalog describes the space as one "fitted with Steam Boilers, Superheaters, Engine, Calorimeter, Indicators, Pressure Gauges, Thermometers, and all the usual apparatus for producing and using steam, and for testing its nature and action."

As the laboratory work developed, the boilers and engines used for heating and ventilating the building, and for driving the ore dressing machinery in the metallurgical laboratory were made available for testing. The lab was used by both engineering and physics students. The course in physics, Mooney writes, included "tests of engines and boilers; evaporation per pound of coal; measurement of power; transmission and absorption dynamometers; coating of steam pipes; friction of belts and pulleys; strength of materials."

In 1883, when Whitaker retired, Gaetano Lanza, then head of the Department of Theoretical and Applied Mechanics, also became head of mechanical engineering. New instructors, including Cecil H. Peabody, joined MechE. Peabody transferred from Applied Mechanics, joining the department as Assistant Professor of Steam Engineering. Not only was he the first faculty member to be specifically designated as a professor of heat engineering, but the legacy of his contributions includes the creation of two significant MIT programs.

In his first year, Peabody helped establish course options in Marine Engineering, Locomotive Engineering, and Mill Engineering. In his first two years, Peabody produced text and data compilations to describe heat engineering instruction in thermodynamics that endured with little change for the next fifty years. He would go on to launch the Department of Naval Architecture and Marine Engineering in 1893, which would remain a separate department for over a century before rejoining MechE as Ocean Science and Engineering in 2005.

MIT's first undergraduate courses in aeronautical engineering also grew out of Peabody's steam turbine program. In 1909, U.S. Naval Academy graduate Jerome C. Hunsaker enrolled in MIT's graduate program in naval construction. While studying, he developed a fascination with aeronautical literature and quickly became interested in aviation. In 1933, Hunsaker became head of mechanical engineering then, under Hunsaker's leadership, in 1939, Aeronautics became a distinct department.

A New Campus

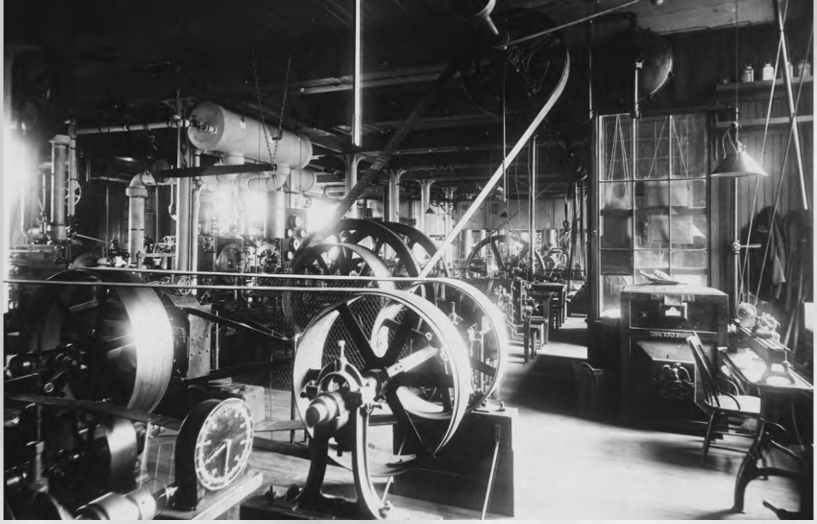
By 1890, Heat Engineering was well-established as a major field of instruction. When MIT moved from the Back Bay to Cambridge in 1916, a new Steam Laboratory was built. This new lab, which occupied a multi-level space in Building 3, was equipped with steam engines of all types, including the Corliss engine, an enormous steam engine patented in 1849 fitted with rotary valves and variable valve timing.

During this time, the mechanical engineering department was headed by Professor Edward Furber Miller. Miller, like Whitaker, had a significant interest in heat engineering. Miller joined MIT as a professor of steam engineering in 1892. He took over as department head in 1911, and held the post until his death in 1933.

Courses in refrigeration, power plant construction, explosion engines, ventilation, automotive engineering, marine engineering, aeronautics, and more, all grew out of instruction in the heat engineering area. As new courses were introduced, new and separate laboratories were created to accommodate these new investigations.

According to a biography written in 1933 by an anonymous author and held in the archives of the MIT Museum, Miller was "largely instrumental in the development of the laboratories of the Mechanical Engineering Department from the modest beginnings in the basement of the Rogers Building to the present extensive equipment in ten or more laboratory divisions now under the Department."

Some of these labs are still operating today, though their names and research areas have evolved with the times. In 1933, Professor C. Fayette Taylor, a pioneer in the development of the internal combustion engine, left his post in the Aeronautical Engineering Department to join Mechanical Engineering as a professor and director of the new Sloan Laboratory for Aircraft



A photo from the MIT Archives labeled "Building A with Corliss Engine in shot," date unknown.
Credit: MIT Museum

and Automotive Engines. Today, the Sloan Automotive Laboratory uses physics-based modeling, experiments, and data-driven machine-learning modeling together to make internal combustion engines more sustainable.

The Heat Measurements Laboratory, which had been part of the Physics Department, transferred to Mechanical Engineering in 1934. MechE had long sent students to use this lab, and Physics was increasingly moving toward the subatomic realm. This laboratory, founded in the 1870's, supplied valuable instruction in heat measurement techniques and was an important source of data on heat transmission coefficients. Today, the Rohsenow Kendall Heat Transfer Lab is home to research in transport phenomena and energy conversion processes for solar energy, fresh water supply, critical materials recovery, solid state transport, nanotechnology, and phase change systems.

By the late 1940's, with a lot of the Steam Laboratory equipment having outlived its usefulness and with growing pressure for space in Institute buildings, much of the large steam and hydraulic equipment was removed to make space for new research and innovation, but the legacy of this important space lives on.

Heat Transfer Today

"The founding vision of MIT was that it would be, not a university, but an Institute of Technology where people learn the science and practical skills to make, build, invent, and maintain new technologies, all to support societal advancement," says John H. Lienhard V, the Abdul Latif Jameel Professor of Water and Mechanical Engineering, who has written extensively about the history of heat engineering and MechE at MIT.

"We tend to work at the leading edge as much as we can," he says. "Being good at solving a problem that lots of other people know how to solve is great, but it doesn't break new ground – so we're often asking 'what is the emergent question that we can tackle.'"

Work on steam engines was important at the time of MIT's founding because steam engines were widespread. There was a lot to be done both in designing them and in making them operate safely. As steam technology advanced, and improved designs and safety measures were adopted, attention turned to other pressing issues – from liquid-fueled engines, to gas liquefaction and low-temperature refrigeration, to nuclear power, along with a host of other topics.

"Our attention in this department remains on problems that have social and economic impact," says Lienhard. "We ask, 'How are we going to make the world a better place?'"

Lienhard found his own answer to that question with efforts to address water treatment. In the mid-2000s, leaning into his expertise in thermal engineering and transport phenomena, his team refocused work to address the problem of clean water supply and scarcity, particularly around desalination technologies.

"We were able to take ideas we developed here, in the Rohsenow Kendall Lab, and move them out into industrial practice where they've had a very big impact," he says. "That's what we can do as researchers, students, professors – when we see something that's important, and we know we can go after it, we have the ability to change the world."

Gradiant, a company spun out from this work, now operates in twelve countries and employs over 1,200 people worldwide.

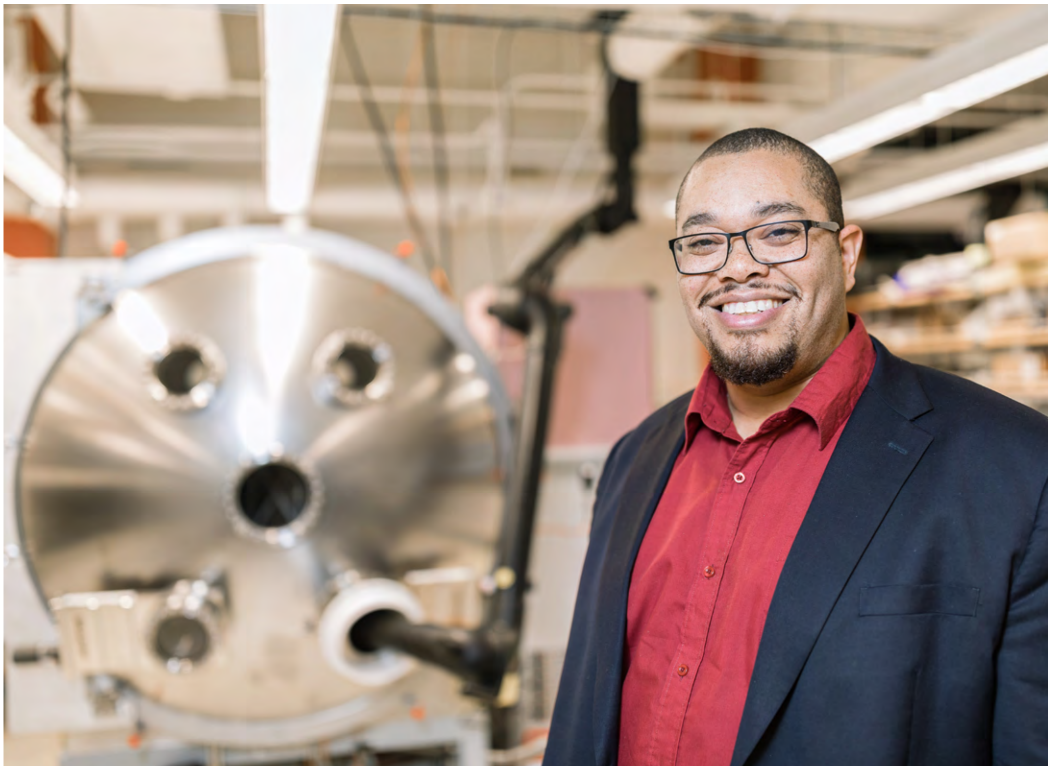
The account by Mr. Mooney, along with a detailed history of the Rohsenow Kendall Heat Transfer Laboratory from 1870 to 1992 written by John H. Lienhard V, the Abdul Latif Jameel Professor of Water and Mechanical Engineering, is available on the RK Lab website at rklab.mit.edu. (rklab.mit.edu/heatengr.html)

Although unconfirmed, Lienhard suspects Mr. Mooney is David A. Mooney, SB 1934. Mooney wrote textbooks on thermodynamics and heat transfer in the early to mid 1950s and also appears in the 1950 MIT Bulletin as an Assistant Professor of Mechanical Engineering.

Record Temperatures

Professor Asegun Henry operates at the extreme end of temperature in industrial applications

Thermodynamics started out as a field with a somewhat singular focus: motion. More specifically, mechanical motion, locomotives, and, ultimately, the conversion of heat to mechanical work. Steam engines, and the desire to better understand the forces that make them work, led to fundamental discoveries about the properties of heat and energy exchange, energy conservation, and later, to the establishment of the laws of thermodynamics.



Speaking as a keynote panelist at the department's 2.150 event, Henry told attendees that his work stemmed from MechE's earliest lab, the Steam Laboratory. "I am a product of that legacy... of steam engines, and heat transfer, and thermal fluids work. I am a part of that continuum," he said. Credit: Ryuji Suzuki

"There was a discovery, or some understanding that you could heat up steam and the pressure would increase, and it could cause something to move," says Asegun Henry, professor of mechanical engineering and founder and CTO of Fourth Power. "That basic physical understanding led to a whole field of trying to understand how to do it better, or control it and make it do different things, so that we could build different devices that ultimately could produce much more force, energy, and power, than any animal on Earth."

Over the last 100 years, a broadening of both fundamental physics and materials understanding has allowed researchers to push further on temperature. As heat flows have increased by orders of magnitude, the temperatures researchers are investigating have increased as well. Today, engineers have far exceeded units like tens or hundreds of horsepower, in terms of the output capabilities of machines.

"Whenever there are two things at different temperatures, assuming these things have some means to communicate energy, there will be heat flow, a rate at which energy is transferred between these two things," says Henry. "Heat transfer engineering is all about to what extent you can control this flow of energy and make it do things that are useful."

Steam turbines remain prevalent in the world of power generation, producing the majority of the world's electricity, and for good reason — degree for degree, they do offer the highest efficiency per temperature unit," Henry says. However, major boundary conditions exist that prevent engineers from going much further.

Conceptually, the efficiency of any heat engine can increase with higher temperatures. Most of what can be done practically with heat transfer, however, is limited by materials. "We just can't make materials that can survive and hold steam at higher and higher temperatures, so we go as high as we can [with steam] and that's the best you can do," he says.

Considering the constraints, he chose to ask a different question. Namely, if you were to just relinquish the constraint of materials for a moment, and say, 'if I want to move heat from one location to the next, what would be the absolute best way to do it.'

Molten tin stores heat and can be used to generate on-demand electricity. Credit: Rob Felt, Georgia Tech

The answer, he says, is to pump a liquid metal.

Throughout his career, Henry has made significant advances and contributions to several energy and heat transfer related fields, including: solar fuels and thermochemistry, phonon transport in disordered materials, and phonon transport at interfaces – he developed the highest temperature pump on record. The all-ceramic mechanical pump can transport liquid metal at temperatures above 1200°C. This technological breakthrough, which is recognized in the Guinness Book of World Records, was later eclipsed by pumping above 2000°C, and has opened the door for new high temperature energy systems concepts.

Inspiring Hands-On Learning

In June of 1916, facing challenges with overcrowding and recognizing a need for more space to accommodate the educational needs brought by new technologies and scientific advances, MIT packed up its laboratories and classrooms that had been scattered in buildings across Boston's Back Bay and crossed the Charles River to settle into its new Cambridge campus.

The move was celebrated with a dedication and three days of events, which included the first public display of the Wright Brothers' 1903 Flyer. The display, arranged by Lester D. Gardner SB 1898, was located in the site of MechE's relocated Steam Laboratory, in what it is, today, the basement and mezzanine level of Building 3.

Professor Sangbae Kim's Biomimetic Robotics Laboratory is one of the labs now located in this space. Before moving into his lab, however, Kim happened upon an historic photo showing the biplane on exhibit. He keeps a print of the photo hanging on the wall in his lab.

"This photo actually is very meaningful – it's not just a cool historic image," says Kim. "If you look at it through the lens of the early 1900s, this photo is a reminder of what MIT stands for – the soul and DNA of MIT, mind and hand, this is a place where you experiment. This is a place where we build and test."

Orville and Wilbur Wright's 1903 Flyer achieved its first flight on December 17, 1903. The flight lasted 12 seconds, traveled 120 feet, and reached a top speed of 6.8 miles per hour – and it changed the course of history. With that flight, the Wright Brothers ushered in the aerial age and established the foundations of aeronautical engineering.

Kim, the Jerry McAfee (1940) Professor in Mechanical Engineering, is not an aeronautical engineer – his lab focuses on designing and controlling bio-inspired robots using insights taken from the natural world – but the practices he wants students to learn and incorporate into their work have origins rooted in the same approaches used by the Wright Brothers.

The Wright Brothers were skilled mechanics. Before they began building aircraft, they built bicycles – planning, designing, and fabricating nearly every part, and learning from the process, which helped inform their aviation experiments. For example, bicycles are highly unstable but controllable machines, which helped them conclude that an airplane could also be unstable yet controllable.

Kim says hands-on experimentation is disappearing from some disciplines today in favor of simulation, which he considers

His work today may represent the most extreme end of temperature, in terms of use in industrial applications. His company, Fourth Power, makes renewable energy available on-demand through utility-scale thermal storage that leverages an extremely power-dense liquid metal-based heat transfer system.

Fourth Power's thermal battery stores energy as sensible heat in graphite blocks between 1900-2400°C (3450-4,350°F) charged by molten tin. The tin is heated using electricity from solar panels or wind turbines and transfers it to carbon blocks during charging. Later, when electricity is needed, the liquid metal extracts the heat from the carbon blocks and photovoltaic panels tuned to infrared light absorb the emitted thermal energy from the piping network. A heavily insulated argon-gas enclosure system ensures that the battery only loses about 1 percent of its energy per day. The system is also designed to have no corrosion and has an expected life of over 30 years.

Henry started his research career working on civil applications, modeling controller performance for earthquake mitigation in high-rise structures. He moved to studying atomic vibration with molecular dynamics simulations, and later began to incorporate first-principles calculations and quantum molecular dynamics simulations. His Atomistic Simulation & Energy (ASE) research group at MIT studies heat transfer, with an emphasis on understanding the science of energy transport, storage, and conversion at the atomic level, along with the development of new industrial-scale energy technologies to mitigate climate change.

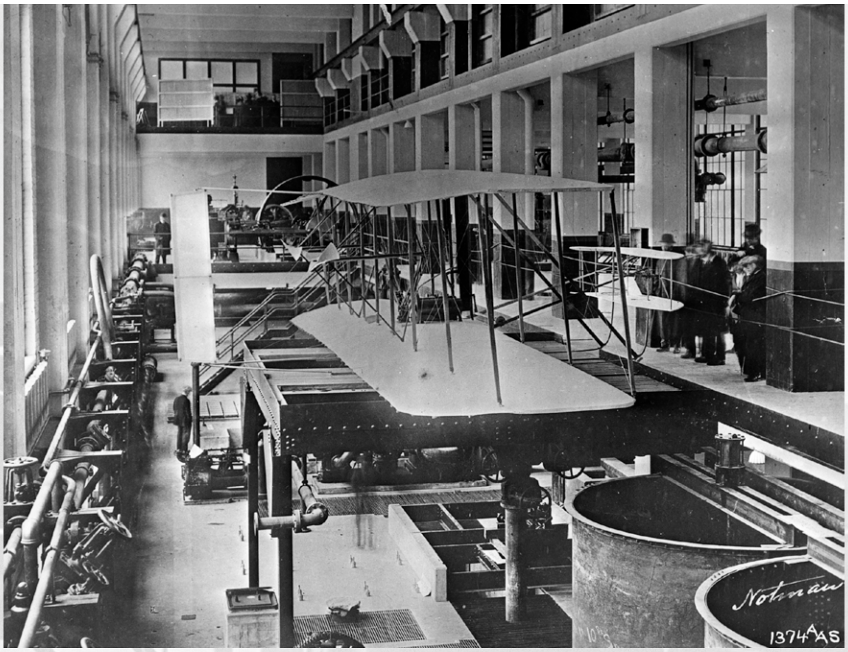
"I think we've started to crack the door open on a whole world of new things you can do at unbelievably high temperatures, because we have shown that you just need to relinquish the constraints and the norms that we're used to."

a major loss. He says he believes students learn best when they can "feel the equation."

"Simulations can be great – they can, for example, save money and time, but there are a lot of things you can't simulate, you have to verify with experiments," says Kim, citing his work in robotics. "There are a lot of things you can't understand until you actually feel your robot behave a certain way, then you can connect that with the equation."

Kim says this is what MIT's mission, "*mens et manus*," mind and hand, is all about. It's not about creating teams where some individuals have a command of the "mind" piece, and others carry out "hand" tasks, but rather to empower each individual to actively understand physical concepts through different representations – equation, force, visuals, data, and more – in a connected way, so that mind and hand are one. "We shouldn't lose that spirit, and the picture is a reminder of that spirit," he says.

According to the Smithsonian Institute, the 1916 exhibition at MIT marked the first time the Wright Flyer had been uncrated and assembled since it flew at Kitty Hawk in 1903. Orville Wright personally attended MIT's campus dedication celebration. The biplane made several stops in the years that followed, before landing a permanent home in the Smithsonian in Washington, D.C. in 1948. In December 2003, a replica of the plane was erected on top of the Great Dome by student hackers, in honor of the 100th anniversary of human-powered flight.



The Wright Flyer on display at MIT in 1916. Credit: Smithsonian Archives

MIT's wind tunnel, now a "modern subsonic, continuous-flow, closed-return tunnel" still bears the Wright Brothers' name.

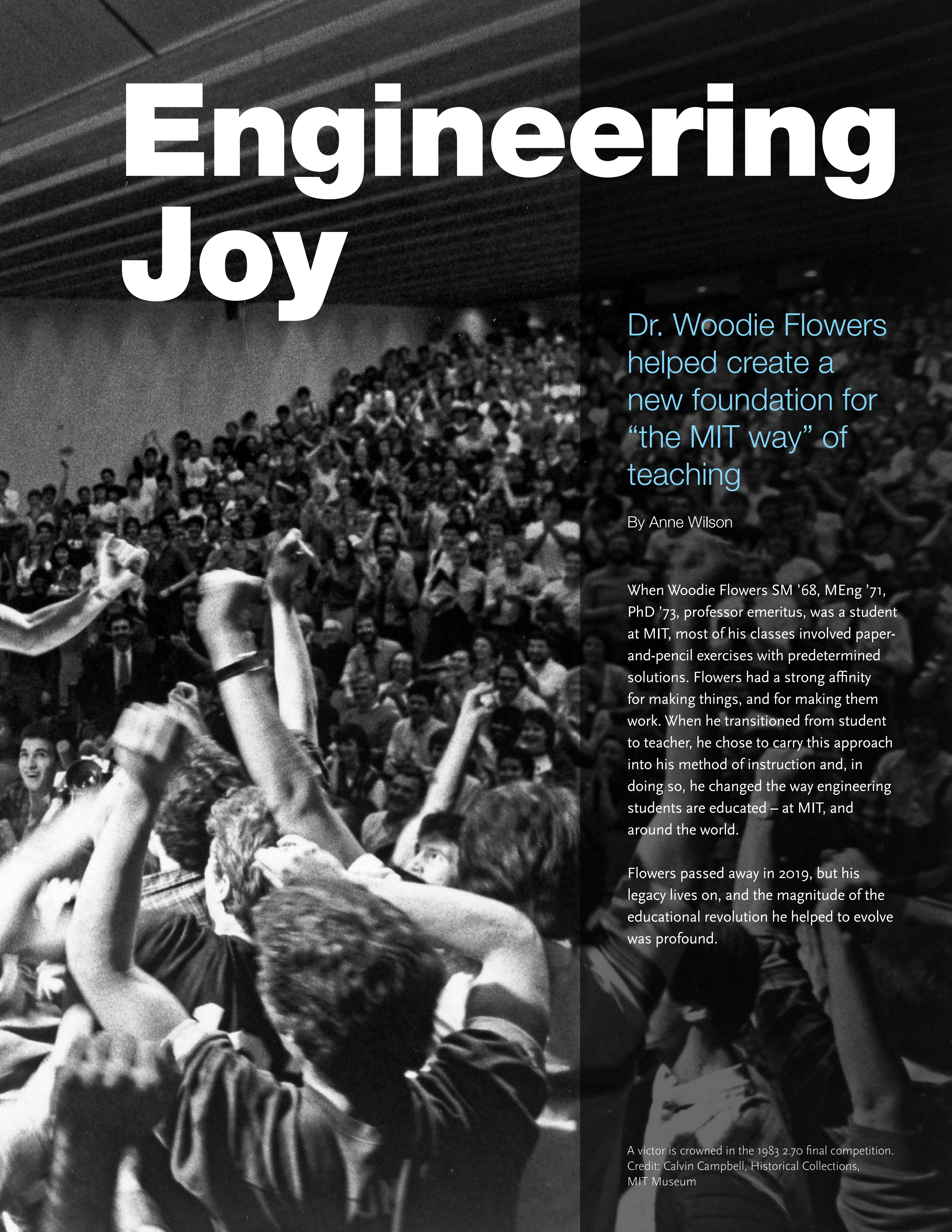
Engineering Joy

Dr. Woodie Flowers helped create a new foundation for “the MIT way” of teaching

By Anne Wilson

When Woodie Flowers SM ’68, MEng ’71, PhD ’73, professor emeritus, was a student at MIT, most of his classes involved paper-and-pencil exercises with predetermined solutions. Flowers had a strong affinity for making things, and for making them work. When he transitioned from student to teacher, he chose to carry this approach into his method of instruction and, in doing so, he changed the way engineering students are educated – at MIT, and around the world.

Flowers passed away in 2019, but his legacy lives on, and the magnitude of the educational revolution he helped to evolve was profound.



A victor is crowned in the 1983 2.70 final competition. Credit: Calvin Campbell, Historical Collections, MIT Museum

Flowers with a student in a 2.70 lab, circa 1986-1987. Credit: MIT Museum, 1986-87 Report to the President

In the 1970s, Flowers took over instruction of 2.70, now called 2.007 (Design and Manufacturing I). The capstone course is one that many first-year students today look forward to taking, but that wasn't always the case. Before Flowers took over instruction, class instruction relied heavily on chalkboard demonstrations.

"Their idea of design at the time was to draw drawings of parts," explains David Gossard PhD '75, professor emeritus, and Flowers' longtime friend and colleague. "Woody had a different idea. Give the entire class a kit of materials [and] a common goal which was to build a machine – to climb a hill or pick up golf balls or whatever it did – and make a contest out of it. It was a phenomenal success. The kids loved it, the faculty loved it, the Institute loved it. And over a period of years, it became, I think it's fair to say, an institution."

With Flowers at the lead, 2.70 transformed into a project-based, get-your-hands-dirty, robotics-competition-focused experience. By all accounts, he also made the experience incredibly fun – something he valued in his own life. He was fond of skydiving and was often seen rollerblading through the Infinite Corridor. The course, informed by his unique style, was at the forefront of a revolution in engineering education, and it quickly helped solidify MechE's reputation for innovative education.

"A lot of kids had never started from scratch and built anything," Flowers once told the *Boston Globe*. His advisor, Professor Robert Mann, had similar beliefs in a hands-on, modern pedagogy. Building on Mann's philosophy, and incorporating his own approach, Flowers breathed new life and provided a new foundation for "the MIT way" of teaching. This was a reinvigoration at the right place and the right time that ultimately had a global butterfly effect on the popularity of Science, Technology, Engineering, and Math (STEM) instruction.

"Over the years lectures had displaced the hands-on stuff, and Woodie brought it back," says Sanjay Sarma, the Fred Fort Flowers (1941) and Daniel Fort Flowers (1941) Professor in Mechanical Engineering. "I can't think of a single person to have impacted the field of robotics and design in undergraduate, or high school, education as much as Woodie."

Flowers became interested in mechanical engineering and design at a young age, thanks in large part to his parents. His father was a welder with a penchant for tinkering, inventing, and building, his mother was an elementary school teacher. Flowers grew up taking things apart and putting them back together – an activity which he believed made students better engineers.

Flowers took part in a skydive while filming a segment for a television show in 1990.
Credit: Stanley Rowin

Speaking with *InfiniteMIT*, a digital archive of Institute history made possible by the generosity of Jane and A. Neil Pappalardo '64, in 2010, Flowers shared a story about a student who had accepted the task in her group of finding out whether a piece of reinforcement steel rebar could be bent into a tight loop and serve as a bearing.

"She came into lab and I was there early, and she had a slightly bent piece of rebar. It had been heated – you could tell that it had been hot, and she was going to report that she really can't do that, it just kind of doesn't work," Flowers recalled. He suggested they try another approach.

"We went out in the lab and I found another big steel bar and I found the biggest vice I could find," he continued. Flowers cranked the rebar down against the piece of steel he was going to wrap it around, then took a four-pound sledgehammer to it. "My father had a blacksmith pit, so that was familiar to me. I wrapped [the rebar around the steel and] made a fine bearing. As I finished kind of the last blow, I looked up and three of the best students in the class – really sharp people – were standing there with their jaw open. They'd never seen anyone hit a piece of steel hard enough to just mold it."

"That visceral understanding of the behavior of mechanics is really important," he said. "It doesn't fall out of the sky and it certainly doesn't come out of a textbook, it comes through real interaction. I believe

Flowers presenting an award at the 2017-2018 FIRST Tech Challenge. Credit: FIRST®

> “Nobody is getting hired to solve the multiple-choice problems at the end of the chapter.”
>
> – Woodie Flowers, SM ’68, ME ’70, PhD ’72 (1943-2019)

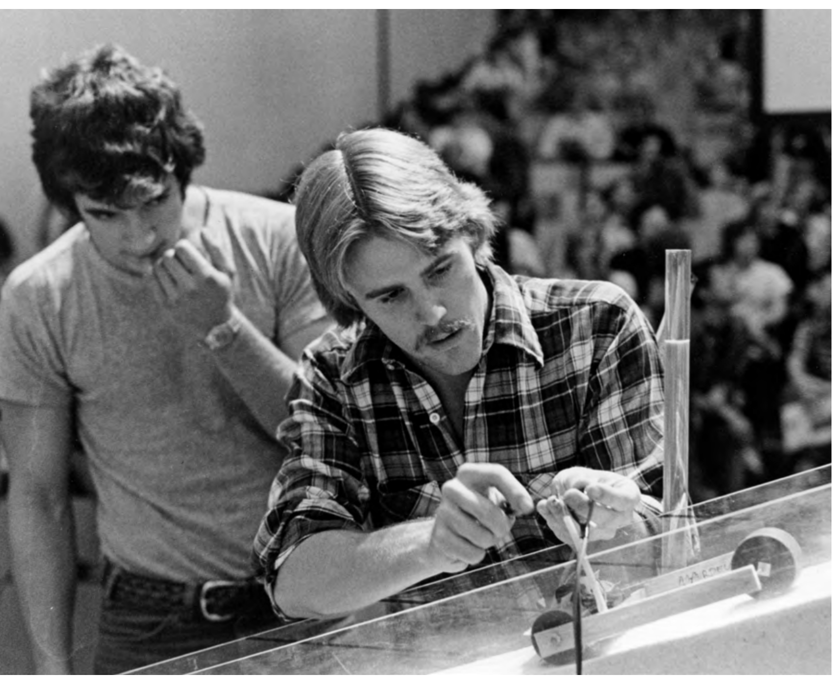
I had been so lucky because when I encountered Castiglione’s theorem about deflection of materials, it kind of made sense.”

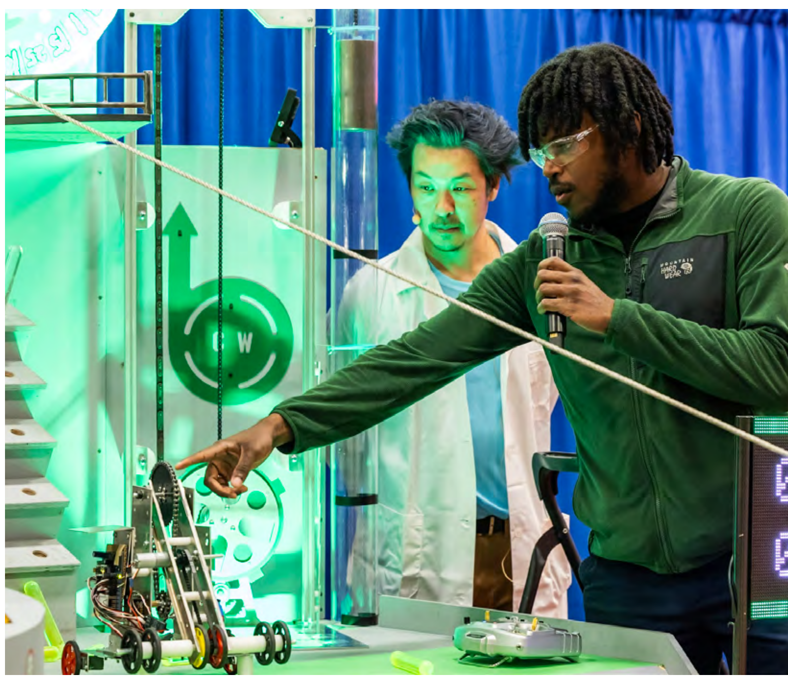
2.70/2.007 is considered a landmark class in engineering education. It was one of the first hands-on classes to teach students not only how to design an object but also how to build it and, by demonstrating the value of practical, project-based learning and robotics competitions. It has influenced the approach taken by many other programs. Today, it continues to develop students’ competence and self-confidence as design engineers, with an emphasis on the creative design process bolstered by application of physical laws, robustness, and manufacturability.

Notably, the course also served as the inspiration for development of the FIRST Robotics program, which was started by Flowers and inventor Dean Kamen in 1989. FIRST has programs for preschool through high school students and, to date, more than 3.2 million youth from more than 100 countries have participated in FIRST competitions.

In the 1970s, the parts kit – or as Flowers fondly referred to it, the “bag of junk” – included things like springs, tongue depressors, and rubber bands. Today, in addition to using the kit of mechanical parts and materials, students might develop 3D printed components, and they incorporate electronics in their robots for an autonomous portion of the final competition.

The spring 2024 competition, themed after Cartoon Network’s popular animated science fiction sitcom Rick and Morty,





(Left) A photo of 2.70 students dated circa 1977. Credit: Jeff Stein. (Right) Professor Sangbae Kim looks on as a 2.007 student presents his robot during this year’s competition. Credit: Tony Pulsone

Flowers looks on as a 2.009 student discusses work.
Credit: 2.009 students and staff

featured a spaceship that students' robots could interact with for points, vats of "acid" where balls could be collected and placed in tubes, and game pieces that paid homage to iconic episodes. The final task required the robot to travel up an elevator and send a character down a zipline.

In recent years, other themes have centered on tasks related to "Star Wars", "Back to the Future" and "Willy Wonka". The 2022 theme, however, may have been the most poignant theme to date: "Legacy," a celebration of Flowers' life and work.

"[Woodie] revealed, unambiguously, that designing, fabricating, assembling and building things was fun," says Gossard. "It was arguably the essence of engineering. There was joy in it."

Video extra: Woodie Flowers' colleagues and former students reflect on his life and impact:

Pioneering Pedagogy

Before Woodie Flowers, his advisor Robert Mann advocated a place for design in engineering education

By Anne Wilson

Dr. Robert Mann, an engineer and former rocket scientist who developed the world's first biomedical prosthetic device, was instrumental in turning design into a discipline. As engineering education shifted from an emphasis on mostly empirical to mostly theoretical, Mann advocated for balance and a place for design.

In the 1960s, Mann introduced project-oriented courses that involved students in the design process, transforming the design curriculum in mechanical engineering at MIT. He also wrote extensively about the importance of this effort. Woodie Flowers, one of Mann's advisees, later took up the charge, using what Mann had outlined to inform the development of 2.70/2.007.

"My academic career of more than 50 years has been committed to involving undergraduate and graduate students in the engineering design process," Mann wrote in a supplement published in 2002 by the *Journal of Rehab R&D*. "A variety of experiences—childhood model making, vocational high school education, draftsman jobs, and military assignments during World War II—have convinced me that one learns to design by being required to design."

Mann joined the MIT faculty in 1953, serving as a professor of mechanical engineering for almost 40 years. Through the years, he also served as Whitaker Professor of Biomedical Engineering and as director of MIT's Eric P. and Evelyn E. Newman Laboratory for Biomechanics and Human Rehabilitation from 1974 until his retirement in 1992.

During the 1950s, his research on internal power systems led to the development of Sparrow I and III and Hawk missiles. By the mid 1960s, his research was focused primarily on applying technology to human disabilities.

Mann was involved in development of the Utah Elbow and the MIT Knee, shown here working with Flowers, who was then a graduate student.
Credit: MIT Museum

"At MIT, first as a research engineer and then as faculty, I mounted an unending search for appropriate topics to develop into engineering design goals as well as thesis topics for my students," Mann wrote. "As part of that search, I became involved in rehabilitation engineering (RE)… [and] for my students, as well as for me, RE proved a winner! Students were challenged technically while working on projects that had real human significance—that indeed would ultimately improve the quality of life for thousands of people. The prospect of making such contributions attracted the best students to my research projects."

Mann inaugurated the Sensory Aids Evaluation and Development Project in 1964, from which English-to-Braille computer translation systems, the award-winning MIT Braille Embosser and electronic travel aids for the blind resulted. His Boston Arm was the first artificial limb to rely on a combination of biology and technology for its control.

2.150 Event

MechE Milestones

MIT celebrates the 150-year anniversary of its first lab opening and its designation as Course 2

By Anne Wilson

"Dear Sir: Since my report to you, made one year ago, quite important changes have been made in the course of instruction in this department. Two principal causes have led to these changes. They are, 1. The entire reorganization of the courses of instruction carried on at the Institute. 2. The existence of the long desired Mechanical Engineering Laboratory." - Professor Channing Whitaker, 1874 Report to the President

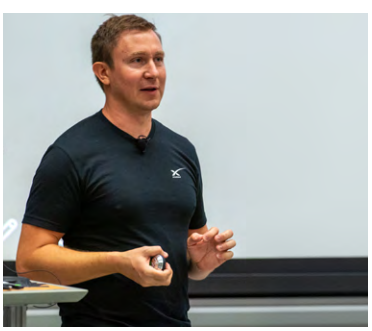
Among the artifacts Professor John Hart found while moving into MechE Headquarters when he began as Department Head in the summer of 2023 were several photographs and documents capturing the earliest years of the department. This led him to the writings of Professor Channing Whitaker, S.B. 1869, in the "1874 Report to the President." Whitaker served as head of mechanical engineering courses from 1873 to 1883.

"In the report, Whitaker details a big change in the curriculum and the establishment of the department's first lab," shares Hart. "Around this same time, 150 years ago, we swapped numbers with Civil Engineering, and officially became Course 2."

The study of mechanical engineering at MIT dates back to the founding of the Institute in 1861. In fact, when the first students enrolled in 1865, of the six courses offered, mechanical engineering was designated as Course 1. The reason for swapping course numbers isn't known for sure but Hart theorized it may have been related to enrollment – at the time, civil engineering had many more students than mechanical engineering.

The founding of the Steam Lab, described earlier in this issue, marked "the beginning of the department's close relationship with the industries for which it trained its graduates," wrote Whitaker in the 1874 Report. Today, says Hart, "Engagement with industry is essential to our work, spanning from industry mentorship of student projects to internships and collaborative research. The early faculty and students of MechE were pioneers in this regard."

MechE has long embraced our Course 2 moniker, and coupling this with the introduction of the first laboratory invited a celebration.



(Top Left) Keynote panelist Alice Brooks '10 shows off the yo-yo she made in 2.008. (Bottom Left) Keynote panelist Joe Petrzelka PhD '12. (Right) 2.150 attendees participated in lab tours, where students and faculty shared current research. Credit: Tony Pulsone

2.150 attendees were invited to the annual de Florez Competition. Credit: Tony Pulsone

On May 14 and 15, 2024, MechE hosted a symposium to mark this period of change and showcase the department's history and impact. The two-day long event welcomed guests from around the country, immersing them in research and education programs and – through lectures, lab tours, and events – shared a vision for the department's future. Hundreds of alumni, friends, industry guests, and MIT community members traveled to campus, with more tuning in to watch event live streams.

The symposium, which was titled *2.150: Celebrating the history and future of Mechanical Engineering at MIT* in a playful numeric nod at MIT's course numbering system, kicked off with The R.B. Wallace Lecture in Ocean Engineering, given by Dr. Grace Young '14, followed by the annual de Florez Competition, and the 2.007 robot competition on Tuesday evening. On Wednesday, attendees enjoyed lab tours, a student awards ceremony, a keynote event with distinguished alumni panelists, and a community reception on Hockfield Court.

The keynote featured Joe Petrzelka PhD '12, VP Starship Engineering at SpaceX, Alice Brooks '10, Partner at Khosla Ventures and Co-founder of Roominate, and Asegun Henry PhD '09, MIT Professor of Mechanical Engineering and Co-founder and CTO of Fourth Power. Each spoke about their career trajectories, and shared perspectives on building technologies and companies at the frontiers of the physical world.

Empowering Futures

Celebrating the career of retired Graduate Administrator Leslie Regan

By Kimberly Tecce

MechE honored the career of Leslie Regan this spring. Regan spent 47 years supporting the department and guiding graduate students through the ups and downs of graduate student life, including personal journeys. From a time when master's and doctoral students composed their theses on typewriters and made copies using mimeograph machines, through the digital practices of today, Regan was there to offer students support and guidance.

"My heart was with the students. To me it was never really a job, it was a lifetime mission. I really loved seeing them grow and helping them if they had issues," Regan told MIT News.

As an academic administrator, Regan served as a guiding force for countless graduate students, helping them navigate challenging processes like securing funding, passing qualifying exams, and completing theses. For many students, particularly international students, she provided a reassuring refuge in a new and sometimes overwhelming environment. The dedication and the kindness that Regan showed to her students is echoed in former students' stories.

In a video message sent for the celebration, Shangzhi Wu SM '81, MBA '84, PhD '85 reminisced about his journey to MIT over 45 years ago, recollecting Regan's kindness and hospitality as she opened her home in Cape Cod to him and his roommate. When Wu's wife later came join him in Cambridge, Regan discovered that they hadn't had an official wedding ceremony. In her characteristic generous manner, she stepped in to organize a celebration at her home, inviting friends to honor the couple's union.

"You were a wonderful help, to me, and all the students in the MechE Department," Wu shared, adding that Regan would always have a place to stay should she visit China someday.

With the support of nearly fifty MechE alumni, the department launched the "Leslie Regan Graduate Student Support Fund." The fund, which will assist MechE graduate students, celebrates Regan's practices as a beloved figure in the department, with mentorship, compassion, and excellence.

Professor Sangbae Kim, Leslie Regan, and Senior Lecturer Dr. Danny Braunstein SM '94, PhD '98 at the 2.150 event reception in May. Credit: Tony Pulsone

2.150 Event

Our History, at Hart

MechE displays in MIT Hart Nautical Gallery given a full refresh

By Kimberly Tecce

Situated near the midpoint of the first-floor hallway of building 5 is MIT Museum's Francis Russell Hart Nautical Gallery, one of the oldest marine technology archives in the United States. This space tells the story of MIT's deep history with the ocean and, for more than a decade, has also been home to a sizable collection of stories, highlights, and artifacts that reveal MechE's history more broadly. The MechE section, last updated around 2009, was due for a refresh – and the planned 2.150 Celebration provided a perfect opportunity.

"This was one of the most rewarding projects that I've had the pleasure to observe during my time in the department. The level of collaboration between faculty, staff and students as they worked side by side to achieve something so significant in such a short period of time was extraordinary," explains Joanne Mathias, MechE's director of administration and finance. "I was genuinely amazed to see how the work progressed each day as I walked by the Hart Gallery on my way into the office. As various elements arrived and were installed, I was continually impressed by the attention to detail. Seeing the history of the department unfold in such a visually impressive way was really remarkable."

The previous displays highlighted the department's seven research areas – mechanics, design and manufacturing, control, instrumentation and robotics, energy, ocean engineering, biological engineering, and micro and nano technology. The displays told the stories of research that captured the breadth of the department, but didn't fully encapsulate MechE's collaborative, innovative, and playful culture.

Departmental leadership formed a committee to spearhead the redesign process, embarking on a collaborative effort involving staff and faculty members, students, and designers who worked together to reimagine the gallery's story, look, and feel. With their charge, the team was determined to both illustrate the department's core mission as well as bring additional values and strengths to bring to the forefront. Central to the planning process were questions like, "What makes MechE unique?" and "How did the department get to where we are today?"

After many brainstorming sessions, the topics selected to be featured were closely related to the evolution of the department and the core values within – the history of MechE at MIT, the latest frontiers of our groundbreaking research, a look at how the past has informed our present, hands-on education, and more through a

MechE's mission, education, and research areas appear on a gallery wall graphic that evokes the MechE logo. A video display shows MechE content. Credit: Tony Pulsone variety of posters, digital displays, and interactive content. The goal was to create a versatile environment that shows the breadth of the department.

MechE's Senior Administrative Assistant for Space Planning Meg Nagle, who played an integral role in the project ensuring that changes to the physical space could be successfully implemented on the project's tight seven-week timeline, fondly recalls the "can-do" approach the team adopted. "Need a ladder and a tall person to take down a 12ft banner? Let's see who is around and what materials we can find! Will a display not fit because there's an unexpected nail? Let's go find a reciprocating saw!" she quips.

The project came together with new displays, a refreshed paint job, more natural light from previously covered windows, brand new video monitors, and a new collection of artifacts.

Visitors now begin with a look at MechE through the years, which highlights a few of the places and ideas that shaped our department's early years. A display showcasing Frontiers of MechE follows, which features six different research projects from two emerging areas within MechE: Next-generation robotics and Artificial Intelligence. Elsewhere in the room, visitors can explore topics like how imagery brings research to life and MechE's commitment to hands-on learning – in fact, they can participate in such learning through a 'guided discovery' with a tabletop experiment designed by Professor Ely Sachs.

"We felt it was our duty to serve as 'scientific historians,' making sure we portrayed the context, chronological timeline, and specifics of each achievement accurately," reflects Professor Carlos Portela, who co-led the development of a Then and Now display alongside Professor Ellen Roche. The display explores the birth and evolution of 3D printing and biomedical devices.

The Frontiers of MechE display focuses on emerging research areas within the department, Robotics, Data, and AI. Credit: Ritu Raman

"What was most exciting to me was seeing the diversity of contributions within a single topic—for instance, with 3D-printed parts that spanned from less than 100 micrometers in height to some parts that almost reached 1 meter," shares Portela.

The 3D Printing timeline begins in 1980 with the 3D Printing Project where the field was founded by Professors Ely Sachs, Michael Cima, Linda Griffith, Samuel Allen, and Nicholas Patrikalakis and extends through contributions in development today, including Portela's research and development of 3D-printed nanomaterials that can absorb impact energy from supersonic microparticles.

"Putting the board together took me back to the times of group projects throughout various stages of my educational career — with one big difference, this time my team members were the pioneers of these topics being presented," he says, sharing a full circle moment that emphasized what participating in the galley project meant to him.

Artifacts are visible from both inside and outside the space through glass display cases connecting the space to the hallway. Visitors and passersby can watch videos of some of the hands-on experiences while also getting a glimpse into some of the projects that have come out of MechE classes and labs over the years.

The department invites you to experience the newly redesigned Hart Gallery for yourself. Whether you're a longtime member of our alumni community or a first-time visitor, the fresh look and improved features are sure to make your visit memorable.

Video extra: Snapshots from throughout MechE History.

Student Spotlight

Historic Inspirations

By Kimberly Tecce

MechE graduate student Benjamin Weizer and recent alumna Audrey Chen ’24 both credit an ongoing passion for design and engineering to one specific MechE course – a course that has also inspired generations before them.

“Classes like 2.007 are how engineers are forged,” says Weizer, who took 2.007 (Design and Manufacturing I) in 2021. “The hands-on learning experience provided a launchpad into this balance and trade-off game between thinking and doing. When I had an idea, I had the materials and means to try it out and quickly see how well it worked which, in turn, informed design decisions. As a result, I was able to develop and iterate much faster without getting lost in my thoughts about why something would or would not work.”

Chen was already somewhat familiar with the class when she arrived at MIT, having participated in high school FIRST Robotics competitions, a program co-founded by Flowers.

“2.007 was one of my favorite classes I took at MIT. I loved the hands-on learning I got designing my own robot, and I learned a lot of machining and design principles,” recalls Chen. “I really appreciated that I had the materials and freedom to try, fail, and try again until I finally got to a design that I was really happy with. I loved seeing the diversity and creativity of designs that my peers produced, and watching the finals was probably one of the most impressive displays of hard work and engineering brilliance I’ve ever seen.” For each, the impact of 2.007 also led to an interest in preserving the history of the course.

Chen, who has a tremendous passion for photography, came across old slides in Flowers’ office while helping with a

Graduate student Benjamin Weizer poses with his 2.007 robot in the Pappalardo Lab. Credit: Tony Pulsone

To help preserve Flowers' legacy, Audrey Chen '24 spent hours scanning slides. The scanned images were passed on to the MIT Museum and the department archives. Credit: Tony Pulsone

cleanout. The slides piqued an interest in how the class has changed over time.

"I believe photographs are important ways we can remember the past and reflect upon our future. I saw this project as a natural merging of my interest in photography and my love for MechE and MIT," says Chen. To ensure this piece of MechE history was well-cataloged, she took on the endeavor of scanning thousands of old slides and donating them to the MIT Museum Archives. "FIRST Robotics was a big part of my high school experience, so I was especially invested in preserving [Professor Flowers'] legacy."

Weizer transitioned his interest into a project for another class, STS.050 (The History of MIT), where he created a comprehensive digital archive with class materials, photos, videos, news clippings, artifacts and more that capture the history of 2.007 from 1970 through today. Through these materials, he observed how the class originated and changed over time as instructors incorporated new techniques and technologies.

"Professor Flowers knew that students could learn about beam bending, and do the math to figure out when a wood beam would break, but believed that students learned about and built intuition regarding these physical concepts by interacting with things like wood beams and feeling them break in their hands," says Weizer. "He designed 2.007 to be a place where students could explore, break things, and publicly demonstrate their ability to conceive something and build it."

As Weizer reflected on his time studying the history of 2.70, along with his personal experience with the course, he connected both to what the future may hold.

"2.007 inspired me to pursue a career in product or machine design because I love designing things that solve problems, and I'm fascinated by how abstract user needs can be translated into engineering theory with physical applications," he says. "These experiences in 2.007 also showed me the importance that instructors have in students' lives. I don't know if I will come back to Academia one day, but if I do it will be because of 2.007."

Chen, now a project manager at Formlabs, recalls the importance of learning the process that the class provides, not just the finished products that the students compete with.

"Before [2.007], I was bouncing around different STEM interests and disciplines, but I just found so much personal satisfaction in building my robot that I knew that it was the right fit for me. It was the first time I felt that my 'book smarts' were concretely applied to a project, and I was so proud of my final project and impressed with my peers. It really made me realize there are so many ways to approach design problems creatively," she shares.

While 2.007 continues to evolve, its core values of hands-on learning and Flowers' legacy continues to enrich the lives of students who enroll in the class and learn by doing. Like Weizer and Chen, these students often grow into engineers who become unafraid to fail, making them unstoppable in the world of design and problem solving.

Ravi Patil '93, SM '95, IT Executive and Storyteller

By Anne Wilson

During his six years at MIT, Ravi Patil '93, SM '95 kept a journal. The 120-page record chronicled "triumph, defeat, and everything in between," but after he left the Institute it was packed away in a box where it sat for years, mostly forgotten.

"Late one night during the pandemic, I cracked open my MIT boxes, effectively opening a personal time capsule," he recalls. "I flipped through my Course 2 bibles in disbelief and eventually found the journal. Once in my hands, I couldn't put it down. I was so inspired and moved by reawakened memories that I did the geekiest thing possible over the next few days: I dictated the whole journal into LaTeX, something I had not used since MIT."

Immersing himself in the richness of his own MIT experience led him to wonder about the experiences of others. "I knew that many aspects of my story were similar to others, but I also knew there would be differences, mysterious unknowns," he says. "My curiosity to hear, craft, and share the powerful human stories of the MIT community led me to launch *INSTITRVE*."

INSTITRVE, which is pronounced "insti-true," chronicles True stories about MIT. Patil describes it as a "trove of wonder, discovery, and madness." Guests have included an alumna who is using her engineering skills to unravel the mystery of her husband's puzzling disease, a *Jeopardy!* Champion facing the unintended consequences of fame, and a real-life Will Hunting. Episodes 2 and 3 tell the story of Course 2 alumnus Robert Ratonyi '63, SM '64 who, as a six-year-old, survived the Holocaust. Ratonyi recounts growing up in Hungary, and eventually making his way to MIT to complete his undergraduate and graduate degrees.

"What strikes me in each episode is that there is something invariant and time-independent about MIT culture. Whether I speak with an alum from the 1950s, 1990s, or 2020s, we all have a shared sense of curiosity and wonder as well as a tinge of lunacy that compelled us to willingly undertake the MIT workload," he says.

The MIT experience develops a combination of analytical thinking, hands-on skills, and perseverance to be successful in anything that you pursue, he says, with the caveat that communications skills are paramount to this success.

"During your journey towards that perfect job after MIT, you will interact with a diverse range of people. Some will have deep technical skills and easily grasp your accomplishments. Others will have no technical background and may not fully understand your unique skills. There is one guaranteed way to create meaningful impressions with both of these audiences: personal storytelling. Like a muscle, this essential skill becomes stronger with exercise."

> "There is one guaranteed way to create meaningful impressions with [audiences]... personal storytelling. Like a muscle, this essential skill becomes stronger with exercise."
>
> – Ravi Patil

Today, Patil is director of product management and strategy at Broadcom, where he is responsible for the mainframe security and compliance software portfolio. Before Broadcom, Patil served as head of product marketing and held marketing and strategy leadership roles at CA Technologies and IBM. He began is career in the auto industry working at Ford Motor Company, where he designed fuel system components and streamlined manufacturing processes for worldwide vehicle platforms.

"As mechanical engineers, systems thinking is a natural part of our approach. The

Ravi Patil ’93,SM ’95

experience of working at a global company piqued my interest in a broader set of systems (marketing, finance, sales) required to bring products to market,” he says. “I went back to school full time for an MBA [at the University of Michigan] and have been in the information technology industry ever since, where I’ve led marketing, strategy, and product management teams.”

He says a woodworking hobby helps him stay connected to the tactile experience of mechanical engineering, and he stays actively connected to MIT through a variety of volunteer activities. He’s currently serving on the Board of Directors of the MIT Alumni Association and he previously served as North Carolina Research Triangle Park (RTP) alumni club president, educational counselor, and class officer. He’s also instructed personal storytelling seminars for MIT students.

“We live in a time where the question of what it means to be human is being challenged by things such as artificial intelligence, biological engineering, and climate change,” he explains. “I feel that exploring our human journeys and the consequences of our collective actions is critical to not only our wellbeing, but our very existence.”

Find all episodes of the Institrve podcast at institrve.com

Imagine it, Build it

In 2.679 (Electronics for Mechanical Systems II), a hands-on approach teaches problem solving

By Michaela Jarvis

2.679 (Electronics for Mechanical Systems II) takes students through the process of design, fabrication, and assembly of a printed circuit board (PCB). That process, which has twists and turns depending on each student's project idea, culminates in the incorporation of the PCB into a device — in a sense animating that device to perform a certain function.

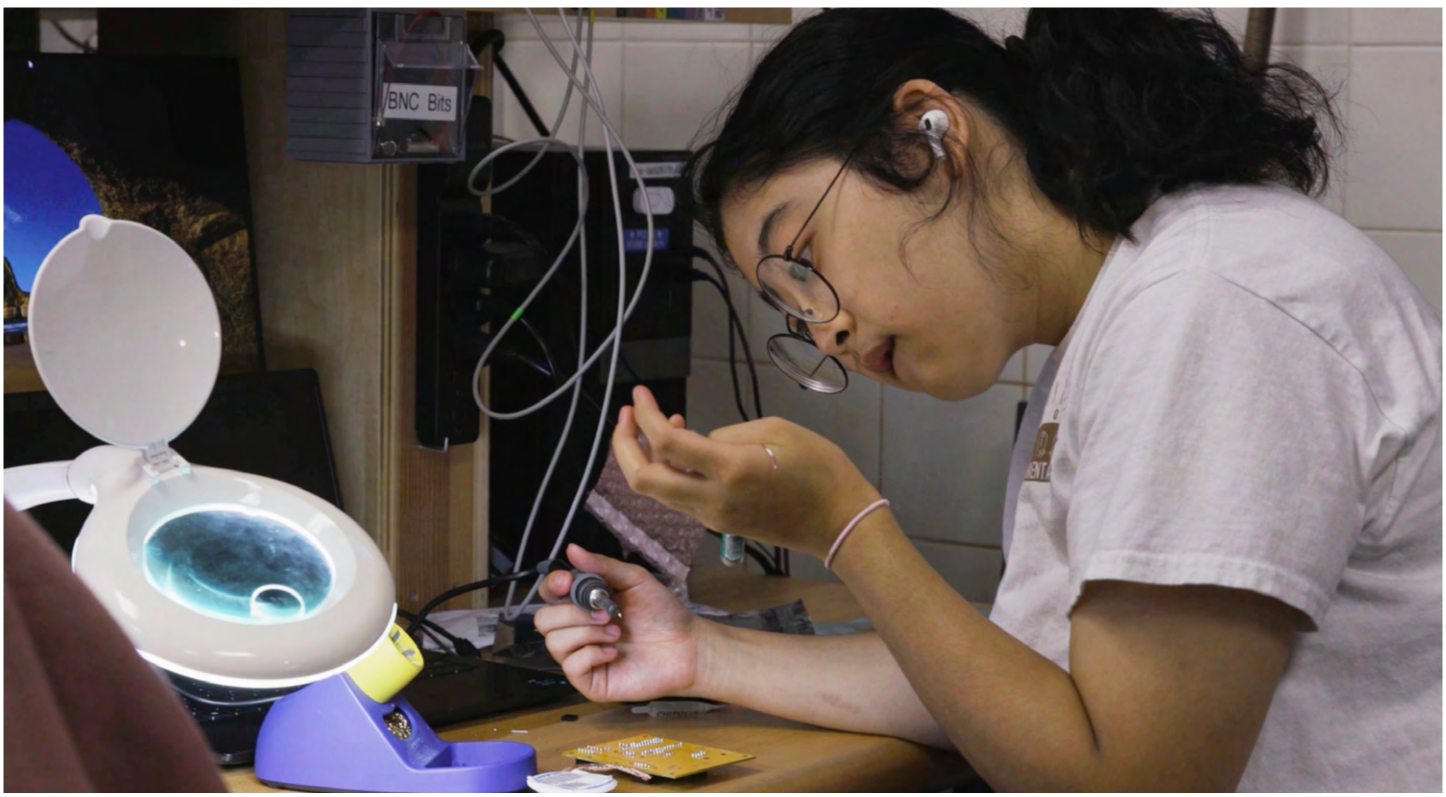
"The design intent of 2.679 is to empower students to 'imagine it, build it,'" says Tonio Buonassisi, professor of mechanical engineering. "Between those two is a universe, and the purpose of this class is to aid aspiring engineers to bridge that gap."

Students say the course offers a sort of alchemy that transforms students from consumers of knowledge to explorers and innovators, and equips them with a range of important new tools at their disposal. Jessica Lam '24 marvels at how much she learned in the course over its one short semester.

"I've found that in a lot of other labs and project-based classes, they throw a lot of information at you at once with the expectation that you already have some experience with certain software or hardware and most of it is scaffolded and feels like a black box," without much understanding of what is actually happening, Lam says. "[Technical instructor] Steve Banzaert has a better understanding of what we already know and how to build on that."

The course left Lam feeling "a lot more confident in designing electrical systems," and with "a more comprehensive understanding of how to integrate mechanical systems and electronics." Which is by design – Banzaert says the class guides students along their own chosen paths of discovery, showing them that they are able to address the challenges they encounter along the way.

MechE undergraduate Jessica Lam works on her design in the lab. Credit: Lauren Futami SM '22

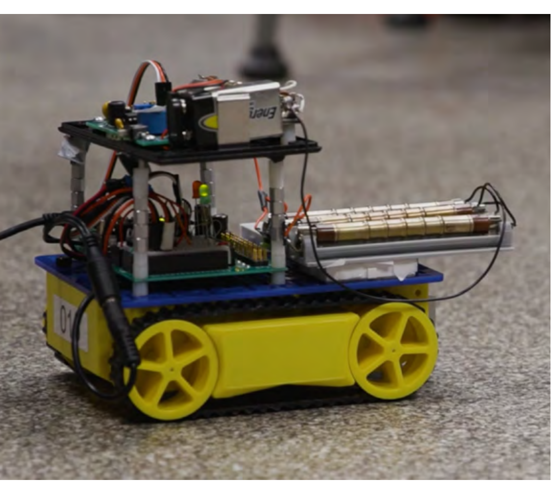


MechE undergraduate student Yasin Hamed with his PCB. Credit: Lauren Futami SM '22

"Every semester we get to see really lovely examples of growth, not just in the course material but, in the best cases, in students' understanding of what they're really capable of," he says.

"We try to make it very clear that, yes, we are talking about important general concepts in theory and analysis, but that's because they are tools that engineers use to solve problems. I think maybe this focus helps remind the students of what got them here in the first place — that the reason you're an engineer is because there's something about the world you wish was better, that you're the person to do it (or at least help), and, if you want to do it well, you're going to have to learn a bunch of things so you have more tools in your toolbox."

Jordan Parker-Ashe's radiation-detecting robot performs a demonstration. Credit: Lauren Futami SM '22



Yasin Hamed '24 designed a car that uses computer vision to follow along black line. The car has an attached camera that captures images and relays them to a Raspberry Pi computer that is also attached to the car. Processing the images in real time allows the car to locate the black line and turn or go straight while controlling the car's speed. Hamed had built a similar system in a previous class, but he says the focus in that class was on software. With his 2.679 project, he learned about the underlying foundation.

"I derived much of the 'enlightenment' from this class from the little electronic bits and pieces of information I picked up along the course of the class, like learning/practicing soldering, understand how to use integrated circuits, learning how to design a PCB, etc.," he says. "It was the collection of all of these things that benefitted me the most."

Jordan Parker-Ashe '24 appreciated how 2.679 combined lessons about electronics with research and presentations from Buonassisi's lab. "It's great seeing engineering applied in research," she says, adding that the class opened up a whole new field to her, with Banzaert having "directly inspired" her to also take 6.131 (Power Electronics).

"2.679 helped me believe in myself, which inspired me to take 6.131, a notorious electrical engineering capstone, which has made me realize that my future lies as a nuclear-electrical engineering engineer, not just a nuclear engineer," Parker-Ashe says. "It's opened the doors to very rich landscapes for project ideas, creating explorations, art... I'm so glad that I've been able to find opportunities in Course 2 that helped give me hands-on, applied engineering experience."

Video extra:
"Imagine it, build it."

There's Magic in Mechatronics

2.737 (Mechatronics) combines electrical and mechanical engineering, but above all else it's about design

By Anne Wilson

MechE graduate student Ronak Roy shares his work with classmates. Credit: Lauren Futami SM '22

The field of mechatronics is multidisciplinary and interdisciplinary, occupying the intersection of mechanical systems, electronics, controls, and computer science. Mechatronics engineers work in a variety of industries — from space exploration to semiconductor manufacturing to product design — and specialize in the integrated design and development of intelligent systems. For students wanting to learn mechatronics, it might come as a surprise that one of the most powerful teaching tools available for the subject matter is simply a pen and a piece of paper.

"Students have to be able to work out things on a piece of paper, and make sketches, and write down key calculations in order to be creative," says MIT professor of mechanical engineering David Trumper, who has been teaching class 2.737 (Mechatronics) since he joined the Institute faculty in the early 1990s. The subject is electrical and mechanical engineering combined, he says, but more than anything else, it's design.

"If you just do electronics, but have no idea how to make the mechanical parts work, you can't find really creative solutions. You have to see ways to solve problems across different domains," says Trumper. "MIT students tend to have seen lots of math and lots of theory. The hands-on part is really critical to build that skill set; with hands-on experiences they'll be more able to imagine how other things might work when they're designing them."

Trumper "really emphasizes being able to do back-of-the-napkin calculations," says Audrey Cui '24, now a graduate student in electrical engineering and computer science. This simplicity is by design, and the critical thinking it promotes is essential for budding designers.

"Sitting behind a computer terminal, you're using some existing tool in the menu system and not thinking creatively," says Trumper. "To see the trade-offs, and get the clutter out of your thinking, it helps to work with a really simple tool — a piece of paper and, hopefully, multicolored pens to code things — you can design so much more creatively than if you're stuck behind a screen. The ability to sketch things is so important."

Trumper studies precision mechatronics, broadly, with a particular interest in mechatronic systems for demanding resolutions. Examples include projects that employ magnetic levitation, linear motors for driving precision manufacturing for semiconductors, and spacecraft attitude control. His work also explores lathes, milling applications, and even bioengineering platforms.

Class 2.737, which is offered every two years, is lab-based. Sketches and concepts come to life in focused experiences designed to expose students to key principles in a hands-on way and are very much informed by what Trumper has found important in his research. The two-week-long lab explorations range from controlling a motor to evaluating electronic scales to vibration isolations systems built on a speaker. One year, students constructed a working atomic force microscope.

"The touch and sense of how things actually work is really important," Trumper says. "As a designer, you have to be able to imagine. If you think of some new configuration of a motor, you need to imagine how it would work and see it working, so you can do design iterations in your imagined space — to make that real requires that you've had experience with the actual thing."

Students enjoy the trial-and-error process that comes with the hands-on, lab-based class. Credit: Lauren Futami SM '22

Woodie Flowers SM '68, MEng '71, PhD '73, used to call it "running the movie." Trumper explains, "once you have the image in your mind, you can more easily picture what's going on with the problem — what's getting hot, where's the stress, what do I like and not like about this design. If you can do that with a piece of paper and your imagination, now you design new things pretty creatively."

Class 2.737 tends to attract students who like to design and build their own things. "I want people who are heading toward being hardware geeks," says Trumper, laughing. "And I mean that lovingly." He says his most important objective for this class is that students learn real tools that they will find useful years from now in their own engineering research or practice.

"Being able to see how multiple pieces fit in together and create one whole working system is just really empowering to me as an aspiring engineer," says Cui.

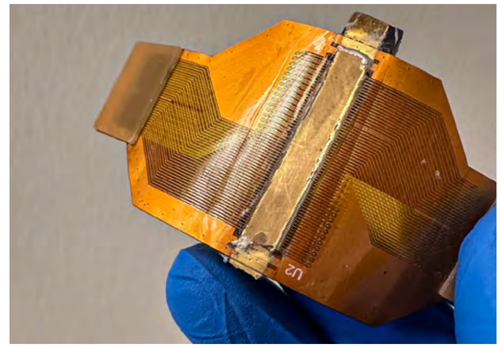
For fellow 2.737 student Zach Francis, the course offered foundations for the future along with a meaningful tie to the past. "This class reminded me about what I enjoy about engineering. You look at it when you're a young kid and you're like 'that looks like magic!' and then as an adult you can now make that. It's the closest thing I've been to a wizard, and I like that a lot."

Professor David Trumper has been teaching 2.737 since the early 1990s. Credit: Lauren Futami SM '22

Video extra:
"A lot like magic."

News & Awards

A small ultrasound sticker, worn on the skin, can monitor the stiffness of organs deep inside the body. The MIT-developed sensor could detect signs of disease such as liver and kidney failure, and the progression of solid tumors. Credit: The researchers



Departmental News

Topping the Lists

QS ranked MIT the world's No. 1 university for 2024-25, ranking it at the top for the 13th year in a row. MIT also placed first in 11 subject areas, including Mechanical Engineering.

2025 Rhodes Scholar

Wilhem Hector is one of four MIT students selected as a 2025 Rhodes Scholar. Hector, the first Haitian citizen to receive this distinction, will pursue a master's in energy systems at Oxford followed by a master's in education focusing on digital and social change. His long-term goals include pioneering Haiti's renewable energy infrastructure and expanding hands-on opportunities in the country's national curriculum.

New Research Funding

The new K. Lisa Yang Global Engineering and Research (GEAR) Center at MIT, founded with a $28 million gift from philanthropist and investor Lisa Yang, and led by Professor Amos Winter, aims to rethink how products and technologies for resource-constrained communities are conceived, designed, and commercialized.

A team of MIT researchers led by Professor Giovanni Traverso received $65.6 million from the Advanced Research Projects Agency for Health (ARPA-H) to develop new ingestible devices that could be used to treat diabetes, obesity, and other conditions through oral delivery of mRNA.

Faculty Promotions

Irmgard Bischofberger to Associate Professor with Tenure. Bischofberger is an expert in the mechanisms of pattern formation and instabilities in complex fluids, through precise experimentation, state-of-the-art imaging, and analytical modeling.

Cullen Buie to Professor of Mechanical Engineering. Buie harnesses his deep technical understanding of microfluidic and biochemical phenomena to develop new technologies that are enabling new biological discoveries, simpler and more accessible laboratory workflows, and scale-up of innovative cell-based therapies.

Sili Deng to Associate Professor of Mechanical Engineering without tenure. Deng is a leader in the study and application of chemically reacting flows, within the domain of combustion. Sili has pioneered scientific machine learning methods for modeling and discovering complex chemical reactions.

Wim van Rees to Associate Professor of Mechanical Engineering without tenure. Rees develops high fidelity numerical methods for fluid-structure interaction problems (FSI) with a focus on ocean engineering applications and inverse design problems.

Manufactured glass bricks assembled in a wall configuration in Killian Court. Credit: Ethan Townsend

MechE Senior Wilhem Hector is a 2025 Rhodes Scholar. Credit: Qudus Shittu

Amos Winter to Professor of Mechanical Engineering. Winter is a world leader in the field of engineering for global development. He combines rigorous engineering science with socioeconomic insights to create high-value products for global markets.

Research Highlights

Professor Kaitlyn Becker and her team are developing a new kind of reconfigurable masonry made from 3D-printed, recycled glass. Using a custom 3D glass printing technology provided by MIT spinoff Evenline, the team has made strong, multilayered glass bricks, each in the shape of a figure eight, that are designed to interlock, much like LEGO bricks. (Journal: *Glass Structures & Engineering*)

A model developed by postdoc Sarah Fay and Professor Peko Hosoi predicts the optimal running shoe design for a given runner. Researchers measure the stiffness of midsole designs using an Instron machine to mimic footsteps. (Journal: *ASME Journal of Biomedical Engineering*)

Professor Xuanhe Zhao and his team developed a small ultrasound sticker, worn on the skin, that can monitor the stiffness of organs deep inside the body. This sensor could detect signs of disease such as liver and kidney failure, and the progression of solid tumors. (Journal: *Science Advances*)

A new prediction method fueled by an MIT-derived algorithm developed by Professor Themis Sapsis and his colleagues helps forecast frequency of extreme weather. The approach "nudges" existing climate simulations closer to future reality. (Journal: *AGU Advancing Earth and Space Sciences*)

Peter Godart PhD '21, Professor Doug Hart, and team have developed a fast and sustainable method for producing hydrogen fuel using aluminum, saltwater, and coffee grounds. (Journal: *Cell Reports Physical Science*)

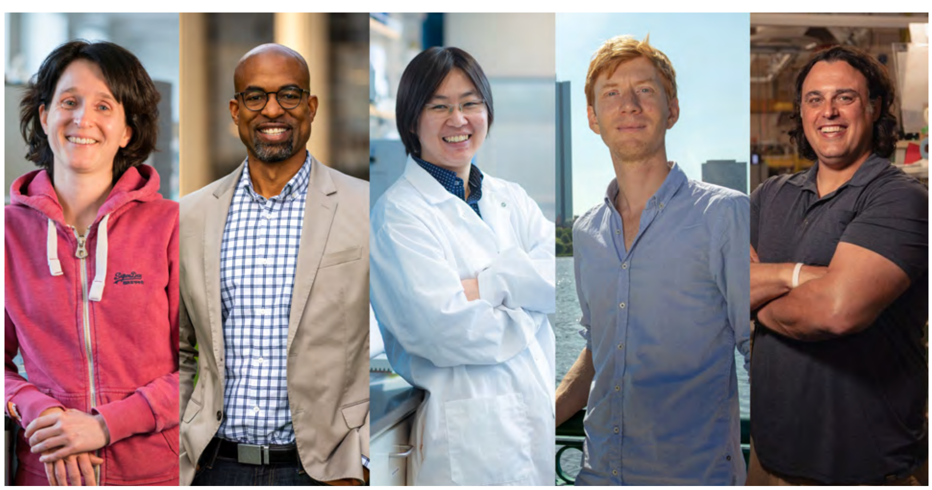
Researchers led by Professor Gang Chen have discovered that light can cause evaporation of water from its surface without the need for heat. The advancement could affect calculations of climate change and may lead to improved desalination and drying processes. (Journal: *PNAS*)

Professor Ritu Raman and team have designed a vibrating platform that could be useful for growing artificial muscles to power soft robots and testing therapies for neuromuscular diseases. (Journal: *Device*)

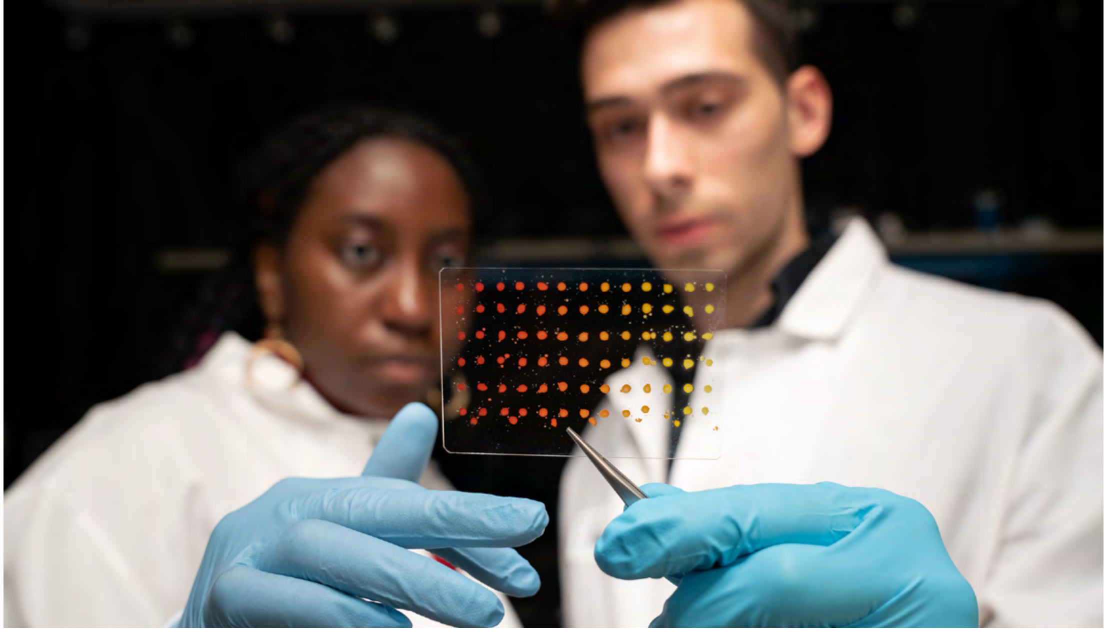
Professor Tonio Buonassisi and team have developed a technique that automatically analyzes visual features in printed samples to quickly determine key properties of new and promising semiconducting materials. (Journal: *Nature Communications*)

New findings from Professor Mathias Kolle describing the first moments of butterfly scale formation could help engineers design materials for light and heat management. (Journal: *Cell Reports Physical Science*)

Professor Giovanni Traverso and collaborators showed that the device can successfully reverse overdoses in animals. The team envisions that this approach could eventually help prevent overdoses in high-risk populations. (Journal: *Device*)



Recently promoted faculty members: Irmgard Bischofberger, Cullen Buie, Sili Deng, Wim van Rees, and Amos Winter



MIT graduate students Eunice Aissi, left, and Alexander Siemenn, have developed a technique that automatically analyzes visual features in printed samples (pictured) to quickly determine key properties of new and promising semiconducting materials. Credit: Bryce Vickmark

Professor Sherrie Wang and her team have developed a method that uses machine learning to analyze satellite and roadside images of areas where small farms predominate and agricultural data is sparse.

Crack patterns formed by drying drops of a colloidal suspension from Bishofberger's research. Credit: The researchers

A new study by Dr. Paul Lilin SM '20, PhD '24, Mario Ibrahim '24, and Professor Irmgard Bischofberger rationalizes the spectacular crack patterns formed by drying drops of a colloidal suspension by considering the energy released by each successive crack. (Journal: *Science Advances*)

Faculty Awards

Professor Peko Hosoi received a Selby Fellowship Award from the Australian Academy of Science for research focused on fluid dynamics, biomechanics and bio-inspired design. The Selby Fellowship fosters the international exchange of scientific ideas.

Ahmed Ghoneim received the 2024 Bernard Lewis Gold Medal from the Combustion Institute. The award recognizes brilliant research in the field of combustion.

Ritu Raman received the MIT School of Engineering 2024 Ruth and Joel Spira Award for Excellence in Teaching and a 2024 Young Investigator Award from the Office of Naval Research.

Marty Culpepper received the 2024 MechE Keenan Award for Innovation in Undergraduate Education.

Daniel Braunstein received the 2024 Mechanical Engineering Exceptional Educator Award for Academic Staff.

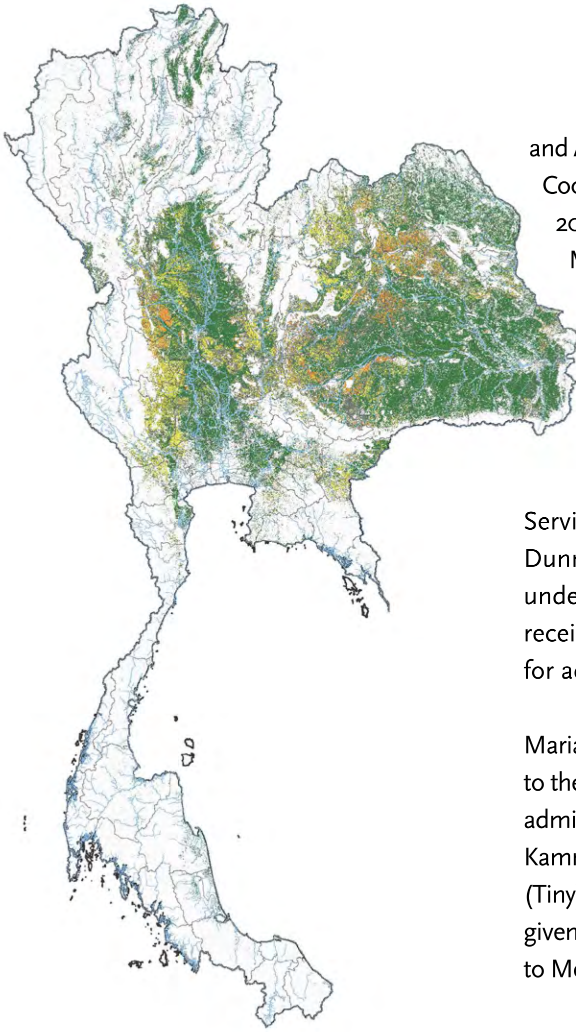
Professor Sili Deng received the 2024 Irvin Glassman Young Investigator Award from the Eastern States Section of the US Combustion Institute. This biennial award is to recognize an early-career investigator within ten years of PhD completion.

Professor Lallit Anand was named a 2024 SES Fellow by the Society of Engineering Science for his contributions to the Society and the technical community.

Associate Professor Betar Gallant received the Electrochemical Society's 2024 Charles W. Tobias Young Investigator Award.

Assistant Professor Carlos Portela, the Robert N. Noyce Career Development Professor, has been awarded an Army Early Career Program Award (ARO ECP). Portela's 3-year effort will focus on understanding the mechanics of granular metamaterials with tunable mechanical properties.

Linda Gjerasi, manager of research administration, with her husband Prio Gjerasi; Theresa Peterson, senior financial officer; and Jason Caloggero, financial coordinator, at the SOE Infinite Mile Award Ceremony. Credit: Gretchen Ertl



The team created a border-to-border map of Thailand's four major crops — rice, cassava, sugarcane, and maize — and determined which of the four types was grown, at every 10 meters, and without gaps, across the entire country. Credit: The researchers

Professors Themis Sapsis, Michael Triantafyllou, and Nicholas Patrikalakis were honored for contributions to the Maritime Industry of Greece during an event hosted by the MIT Club of Greece in Athens.

Professors Domitilla Del Vecchio and Themis Sapsis have been named 2024 Vannevar Bush Fellows. The fellowship is the DoD's flagship single-investigator award for research and invites the nation's most talented researchers to pursue ambitious ideas that defy conventional boundaries.

Staff Awards

Linda Gjerasi, ME-RAS Manager, Michael Skocay, Faculty Affairs Administrator, and Administrative and Community Coordinator, Christina Spinelli received a 2024 MIT Infinite Mile Award. Infinite Mile recognizes individuals or teams who have made extraordinary contributions to help the Institute carry out its mission.

Amazigh Ankji, financial officer in MechE Research Administration Services (ME-RAS), and Emma Dunn Santana, assistant director of undergraduate academic programs received the H. Sharon Trohon Award for administrative excellence in MechE.

Maria Moran, administrative assistant to the Naval Program, and Tyler Butler, administrative assistant to Profs. Ahmed, Kamm, Raman, and So, received the Joseph (Tiny) Caloggero Service Award, which is given to support staff for outstanding service to MechE.

Alumni News

The family of Charles Hansen SB '47 visited campus in November, presenting a check to Professor Gang Chen on behalf of Hansen's estate, to recognize the establishment of the Charles C. Hansen III (1947) Career Development Professorship. Hansen passed away in October of 2023. During his lifetime, he also made gifts to fund the Charles C. Hansen III (1947) Fellowship.

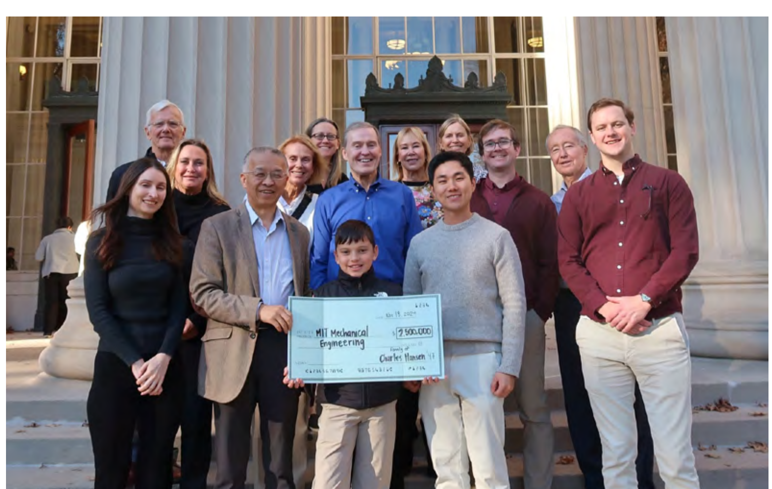
Marcos Berríos '06, Christina Birch PhD '15, and Christopher Williams PhD '12, graduated from NASA astronaut training and are now eligible for spaceflight assignments.

Marcos Berríos '06 wears a spacesuit prior to underwater training at NASA Johnson Space Center's Neutral Buoyancy Laboratory. Credit: Bill Stafford/NASA

Yamilée Toussaint '08 was recently featured on CNN Heroes for her organization STEM From Dance – a program that combines STEM education and the performing arts to make STEM fields more accessible and engaging, and empowers girls of color around the country to explore their abilities in STEM fields.

AeroShield, co-founded by Elise Strobach SM '17, PhD '20, Kyle L Wilke SM '16, PD '19, has opened a facility for manufacturing highly insulating windows that will reduce building energy use and cut carbon emissions. Research on the technology began a decade ago in the lab of Professor Evelyn Wang.

Slice of MIT featured Louise Jandura '84, SM '86, MIT's only four-time Academic All-America honoree. Jandura has worked for NASA's Jet Propulsion Laboratory (JPL) for the past 35 years. She is now the chief engineer for the sampling and caching system on Mars 2020.



The family of Charles Hansen SB '47 on campus with Professor Gang Chen. Credit: Courtesy of the family

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