Mens et Manus:

A History of Mechanical Engineering at MIT

MITMECHE

Mechanical Engineering, one of the six founding courses of study at MIT, embodies the motto *mens et manus* – mind and hand. Disciplinary depth and breadth, together with hands-on discovery and physical realization, characterize our nationally and internationally recognized leadership in research, education, and innovation. MIT mechanical engineers always have stood at the forefront in tackling the engineering challenges of the day: inventing new technologies, spawning new fields of study, and educating generations of leaders in industry, government, and academia.

Today, mechanical engineering is one of the broadest and most versatile of the engineering professions. This is reflected in the broad portfolio of current research and education activities in the department, one that is increasingly multidisciplinary and has widened rapidly over the past decade. Faculty and students are involved in projects that aim to bring engineering solutions to a spectrum of global challenges, ranging from:

• Developing clean and renewable energy technologies, including research in photovoltaics, wind energy, fuel cells, batteries, and carbon sequestration
• Developing new thermal and membrane technologies for water purification and desalination
• Developing the instrumentation, controls, and technologies required for medical therapies and biomedical exploration
• Designing the vehicles, acoustics, and control systems for underwater exploration and environmental monitoring
• Designing the structure, materials, and advanced technologies needed for better protection and security of first responders and soldiers

• Designing, manufacturing, and controlling of precision devices, machines, vehicles, processes, and robotics.

These projects cover the underpinnings of fundamental engineering science up to the design, manufacturing, and fabrication of new structures, devices, and technologies. To meet these challenges, research in the department is broadly coordinated across seven areas:

• Mechanics: modeling, experimentation, and computation
• Control, instrumentation, and robotics
• Design, manufacturing, and product development
• Energy science and engineering
• Ocean science and engineering
• Bioengineering
• Micro- and nano-engineering

The department's three undergraduate degrees prepare students for professional practice in a world of rapidly advancing technology. A rigorous base in the engineering sciences is combined with hands-on laboratory experience. Product design classes encourage novel inventions complete with competitive business plans. A new course featuring nano-/micro-technologies provides undergraduates with an opportunity to build, observe, and manipulate objects at the micro- and nano-scale. MechE's flexible engineering degree enables students to tailor their engineering course selection around a self-selected specialty or multidisciplinary field. A degree from Mechanical Engineering has never been more popular or important than it is today.

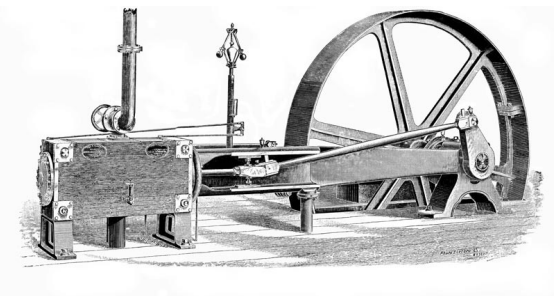
1865:

Six courses of study are offered to the first class of MIT students. Mechanical Engineering is designated Course I, then later renamed Course II in 1873.

- The “General” Course
- Civil and Topological Engineering
- Geology and Mining
- Architecture
- Practical and Technical Chemistry
- Mechanical Construction Engineering

1874:

The department’s first lab is established with the donation of a steam engine, inaugurating a focus on energy and power systems that remains at the core of MechE research today.

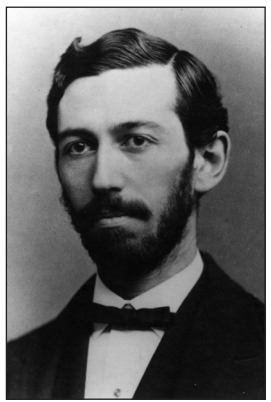


Credit: Institute Archives and Special Collections

1883:

Gaetano Lanza was one of the first to apply scientific methods to many mechanical engineering problems.

The first MIT laboratory for testing full-size structural specimens is established.

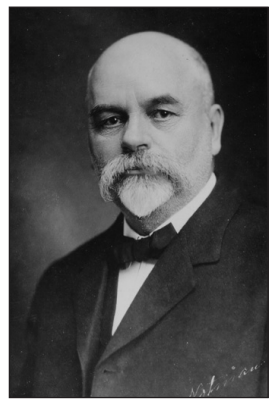


Credit: Mechanical Engineering Archives

1885:

Cecil H. Peabody becomes the first professor of heat engineering.

Within the next two years, he publishes *Tables of Properties of Saturated Steam and Other Vapors*, computed from the original data of Regnault, and invents the throttling calorimeter, used by the process and power industries to determine the precise moisture content of steam.



Credit: Mechanical Engineering Archives

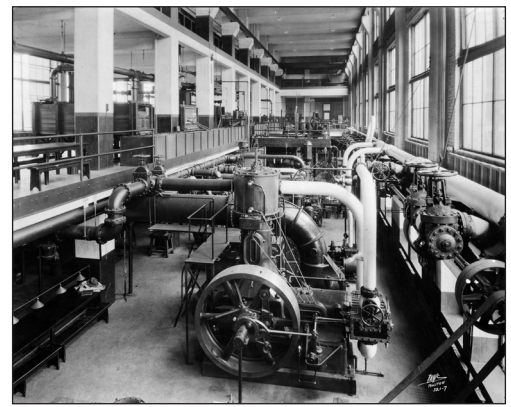
1890:

During construction of the new Boston Public Library, Mechanical Engineering Department Head Gaetano Lanza's tests on Guastavino arches prove the validity of the cohesive construction methods to an American public.

Credit: Boston Public Library

1892:

Edward F. Miller is placed in charge of the steam laboratory, where he would lead a period of rapid growth, including the acquisition and investigation of new types of equipment and numerous demanding field tests on commerical installations.

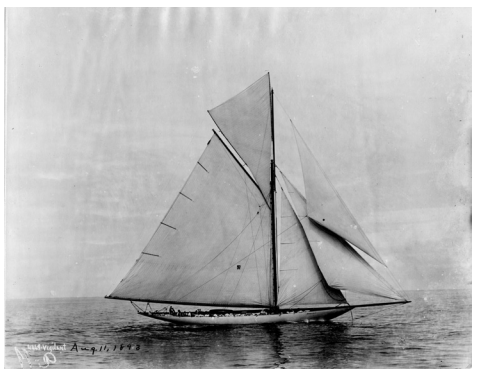


Credit: Mechanical Engineering Archives

1893:

The Vigilant, a boat designed, built, and helmed by Nathanael Herreshoff, Class of 1870, wins the America's Cup race.

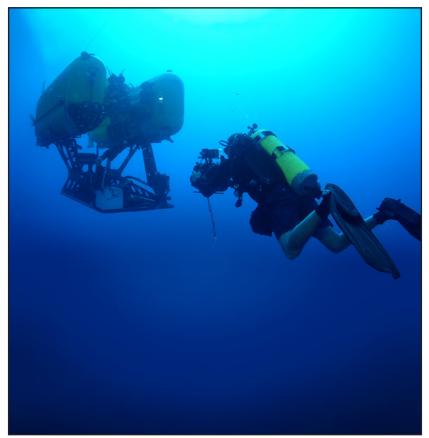
Every winning America's Cup yacht from 1893 to 1934 was built by the Herreshoff yard.



Credit: MIT Museum

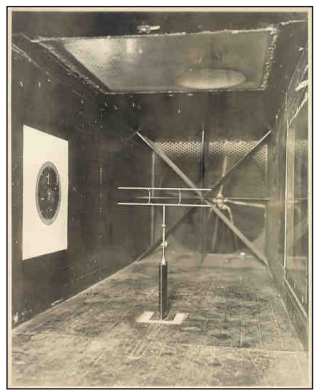
1893:

MechE curricular options serve as the basis for Course XIII, Naval Architecture, which later becomes Ocean Engineering in 1970, then rejoins MechE in 2005.



Credit: Woods Hole Oceanographic Institute

1896:



Credit: MIT Museum

MechE student Albert J. Wells launches the field of aeronautics at MIT when he builds a 30-square-inch wind tunnel as part of his thesis.

He attached a tube to the school's ventilation system to study the effects of air movement on different surfaces.

1901:

A program in Naval Construction is established by Professor William Hovgaard as a collaboration between MIT and the US Navy. Its graduates include many of the Navy's fleet admirals.

Credit: Mechanical Engineering Archives

1902:

Lydia Weld becomes the first woman to receive an engineering degree at MIT. Her areas of concentration are marine engineering and naval architecture. First employed by a Virginia shipbuilder as a naval ship designer, she becomes a full member of ASME in 1935.

Credit: MIT Museum

1908:

The first graduate program in MechE includes coursework in advanced steam and gas engineering, directed readings, and independent research.

Credit: MIT Museum

1912:

Charles Herbert Pratt leaves a large gift to MIT to build the Pratt School of Naval Architecture, the first MIT building on its Cambridge campus, today's building 5.

Credit: Tony Pulsone

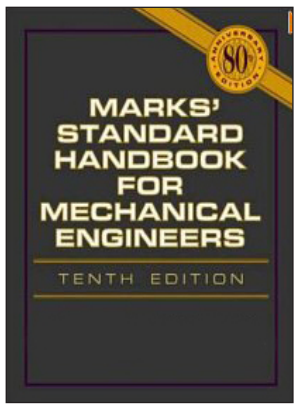
1914:

MechE offers the nation's first course in aeronautical engineering.

The undergraduate program in aeronautical engineering begins in 1926, and Aeronautics becomes a distinct department in 1939.

1916:

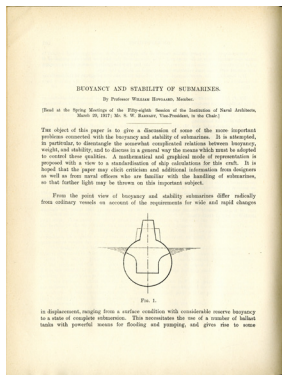
Lionel S. Marks publishes *Standard Handbook for Mechanical Engineers*, a codification of engineering knowledge that is still widely used.



Credit: Mechanical Engineering Archives

1917:

William Hovgaard of Course XIII-A (Naval Architecture and Marine Engineering) publishes *Buoyancy and Stability of Submarines*, for which he is awarded a gold medal by the British Institution of Naval Architects. Hovgaard also testifies as an expert witness on behalf of the White Star Lines during the inquiry that followed the sinking of the HMS Titanic.


BUOYANCY AND STABILITY OF SUBMARINES.

By Professor William Hovgaard, Member.

[Read at the Spring Meetings of the Fifty-eighth Session of the Institution of Naval Architects, March 29, 1917; Sir A. W. Rickman, Vice-President, in the Chair.]

The object of this paper is to give a discussion of some of the more important problems connected with the buoyancy and stability of submarines. It is attempted, in particular, to disentangle the somewhat complicated relations between buoyancy, weight, and stability, and to discuss in a general way the means which must be adopted to control these qualities. A mathematical and graphical mode of representation is proposed with a view to a standardisation of ship calculations for this craft. It is hoped that the paper may elicit criticism and additional information from designers as well as from naval officers who are familiar with the handling of submarines, so that further light may be thrown on this important subject.

From the point view of buoyancy and stability submarines differ radically from ordinary vessels on account of the requirements for wide and rapid changes

Fig. 1.

in displacement, ranging from a surface condition with considerable reserve buoyancy to a state of complete submersion. This necessitates the use of a number of ballast tanks with powerful means for flooding and pumping, and gives rise to some

Credit: MIT Museum

1917:

MechE completes the move to MIT's new location from the corner of Boylston and Berkeley in Boston.

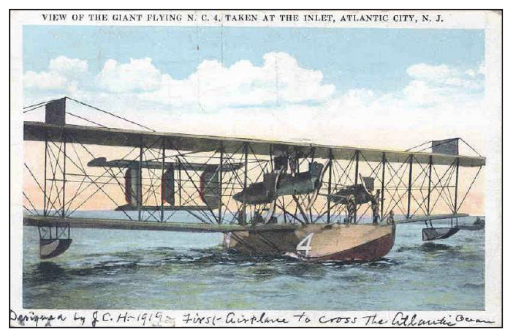
MechE labs are separated into six groups, each headed by an expert in that field who reports to a single director.

1. Steam and compressed air
2. Hydraulics
3. Refrigeration
4. Power measurement
5. Material testing
6. Gas engines

1919:

Jerome Hunsaker designs the NC-4, and in May 1919, it becomes the first aircraft to successfully fly across the Atlantic Ocean.

Later, Hunsaker becomes MechE Department Head, and even later the first Department Head of Aeronautical Engineering.



Credit: Institute Archives and Special Collections

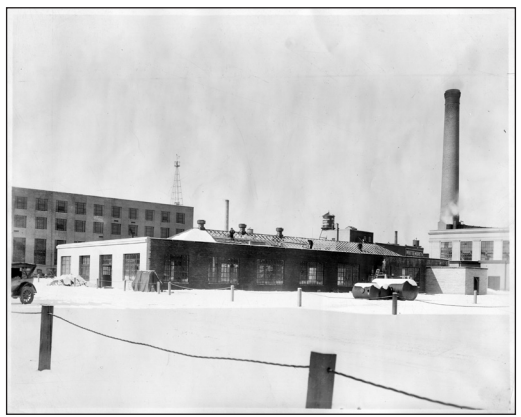
1924:

The Hart Nautical Museum is established, housing an outstanding marine collection.

Credit: MIT Museum

1929:

The Sloan Automotive Lab is established.



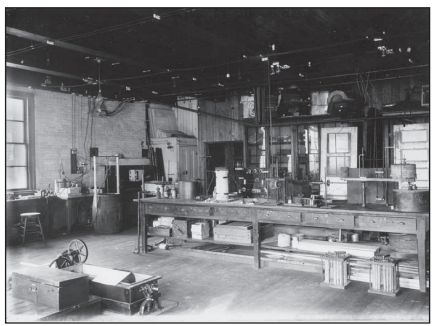
Credit: MIT Museum

1930s:

Fay Taylor's studies of internal combustion engines result in the characterization of IC engine designs.

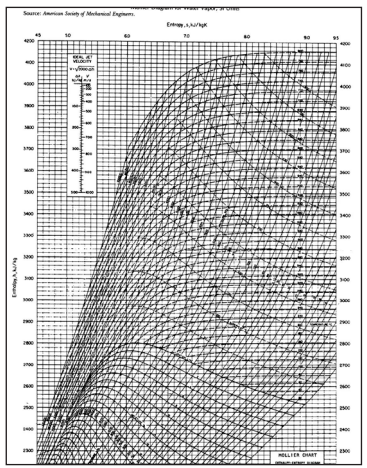
1934:

The Heat Measurements Laboratory, later renamed the Heat Transfer Laboratory, joins MechE. It was originally part of the Physical Laboratory, established at MIT in the 1870s.



Credit: Mechanical Engineering Archives

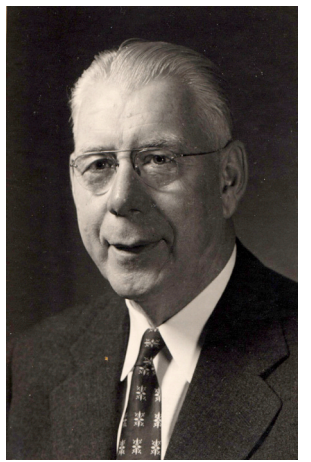
1936:



Joseph Keenan and Frederick Keyes publish *Steam Tables: Thermodynamic Properties of Water*, which remains a standard reference in the analysis and design of power systems.

1938:

President Karl T. Compton's wave of reform brings C. Richard Soderberg to MIT, where he leads the effort to reinvent engineering education, emphasizing fundamental science, the application of basic knowledge to practical problems, and the development of responsibility and critical judgment.



Credit: Mechanical Engineering Archives

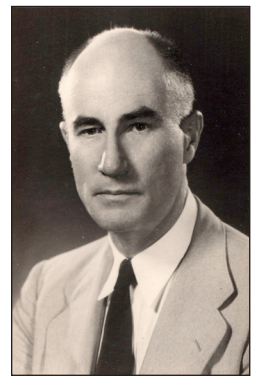
1938:

Professor Frank M. Lewis builds the Propeller Tunnel, used extensively for propeller design in support of the Navy's torpedo development during World War II.

Credit: Mechanical Engineering Archives

1943:

International expert on vibrations Jacob P. Den Hartog is recruited to MIT, bringing Westinghouse design school methods to MechE's teaching of dynamics.



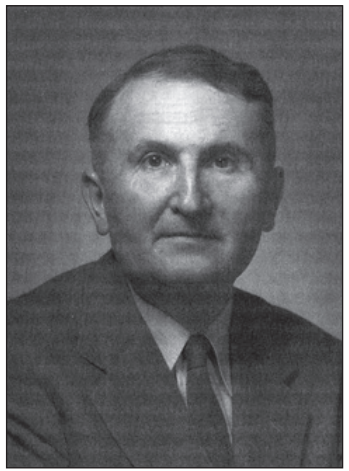
Credit: Mechanical Engineering Archives

1946:

Samuel C. Collins and colleagues perfect a helium liquefier that provides a reliable and affordable supply of liquid helium for research in superconductivity and semiconductors.

Credit: Mechanical Engineering Archives

1950s:



Credit: MIT Museum

E. Orowan describes an early model of dislocation motion in crystals.

1951:

Professor Martin Abkowitz inaugurates the Towing Tank in Building 48, a 108-foot-long tank with an innovative facility used for ship hydrodynamics.

Credit: Mechanical Engineering Archives

1954:

The first Systems Engineering subjects at MIT are introduced by Henry M. Paynter, who transfers from the Department of Civil Engineering to the Department of Mechanical Engineering for this purpose.

Credit: Mechanical Engineering Archives

1956:

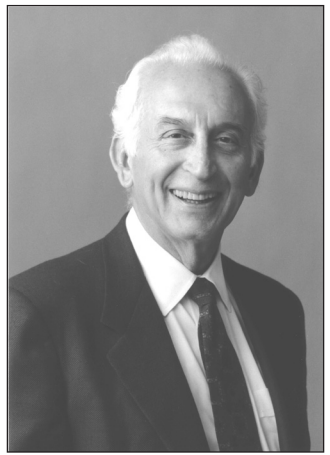
Warren M. Rohsenow becomes director of the Heat Measurements Lab, newly renamed the Heat Transfer Laboratory, which he heads until 1985.

Rohsenow's work has a strong and lasting focus on thermal power conversion, including research on gas turbines, regenerators, heat exchangers, nuclear reactors, and cooling towers.

Credit: Mechanical Engineering Archives

1956:

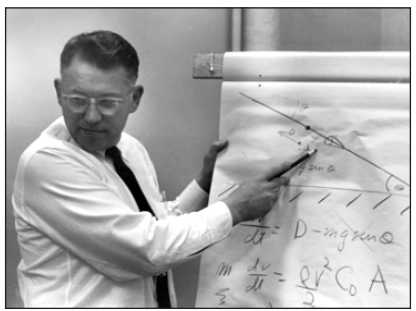
Professor George Hatsopoulos leaves MIT to launch the technology company ThermoElectron to commercialize thermionic energy systems that directly convert heat into electricity. He has the idea that they can be used as generators for applications such as spacecrafts. The company grows rapidly as a result of George's unusual foresight and novel applications of the principles of thermodynamics.



Credit: Mechanical Engineering Archives

1957:

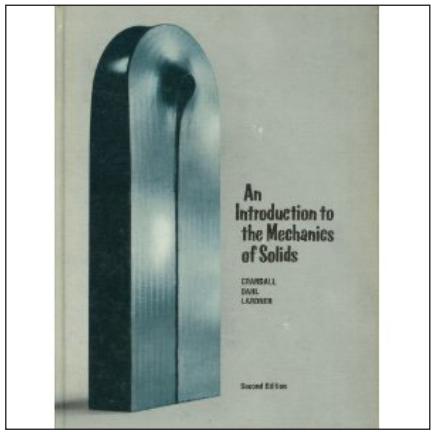
H. Guyford Stever chairs the NACA Special Committee on Space Technology that develops the plan for the National Civil Space Program.



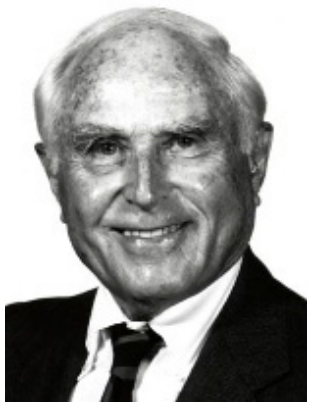
Credit: Mechanical Engineering Archives

1959:

An Introduction to the Mechanics of Solids, by Stephen Crandall, Norman Dahl, and Thomas Lardner, provides the framework of equilibrium, kinematics, and constitutive response for the teaching of mechanics.



1959:



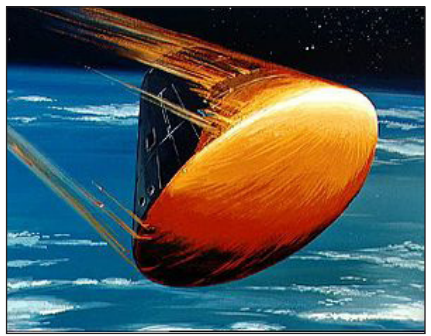
Credit: MIT News Office

A leader in fluid mechanics research and education, Professor Ascher Shapiro begins studying the problems in physiology and medicine that could benefit from an engineering approach.

1959:

Professors Ronald F. Probstein and Wallace D. Hayes publish *Hypersonic Flow Theory*, which remains the principle source of information on the subject.

Probstein later applied these findings to the design of early American spacecraft and ballistic missiles to enable their reentry into the earth's atmosphere without destruction from the high temperatures generated by hypersonic speeds.



Credit: Mechanical Engineering Archives

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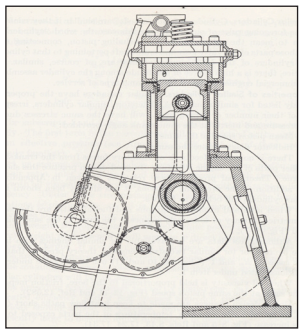
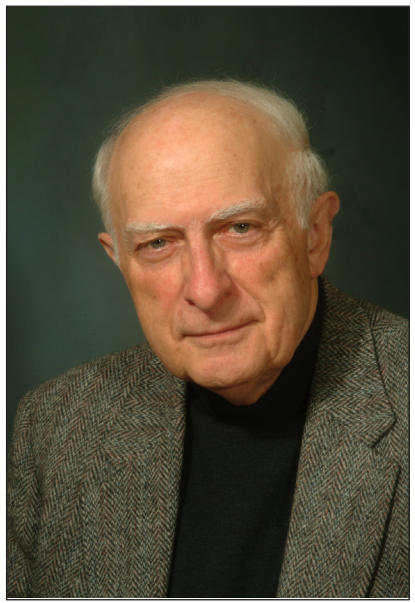
1960:



Former Director of the Sloan Automotive Lab Charles Fayette Taylor publishes the *Internal Combustion Engine in Theory and Practice: Volume 1—Thermodynamics, Fluid Flow, Performance*. It remains the primary textbook in engineer design until John B. Heywood produces *Internal Combustion Engine Fundamentals* in 1988.

Credit: Alibris.com

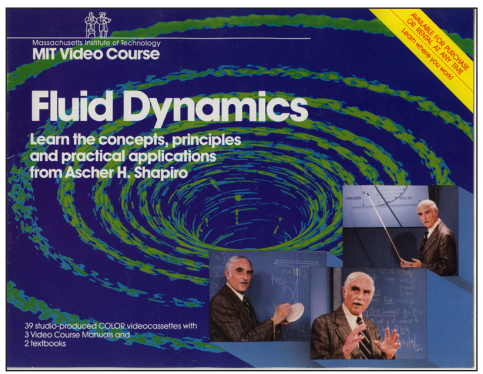
1960:



Ali S. Argon begins his academic career at MIT, where, over the next five decades, with his many students, he conducts seminal experimental and theoretical research and computational simulations elucidating fundamental connections between microstructure and macroscopic deformation and fracture behavior of nearly all engineering solids. He is later recognized as one of the world's leading experts on the mechanisms of inelastic deformation and the fracture of engineering materials.

1961:

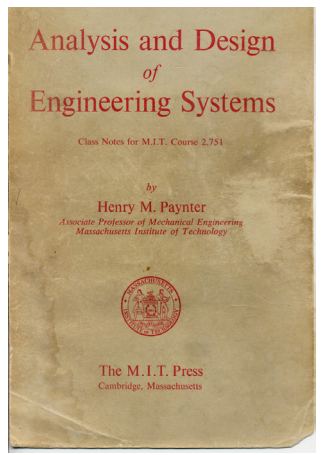
Ascher Shapiro begins producing a series of films that will introduce generations of students and practicing engineers to the complexities of fluid flow.



Credit: Mechanical Engineering Archives

1961:

Henry M. Paynter's *Analysis and Design of Engineering Systems* formalizes the conceptual framework and corresponding notation of bond graphs, an influential modeling language for describing dynamic models.



Credit: Mechanical Engineering Archives

1963:

Professor Ascher Shapiro helps to optimize the function of the intra-aortic balloon pump by preventing the ends from inflating first.

The pump allows doctors to use much less invasive techniques in treating cardiovascular problems.

Credit: Mechanical Engineering Archives

1963:

Random Vibration in Mechanical Systems, by Stephen Crandall and William Mark, merges vibration theory and probability theory to describe the complex disturbances that challenge the integrity of real-world systems.

1964:

Norman C. Dahl leads the Kanpur Indo-American Program, a consortium of nine American universities, in setting up the research laboratories and academic programs of the Indian Institute of Technology in Kanpur.

Credit: Indian Institute of Technology

1960s:

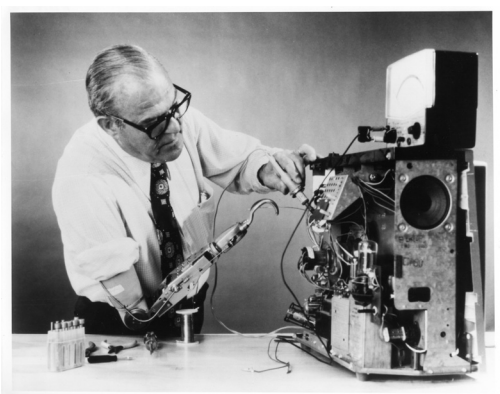
Credit: MIT News Office

Fiber and polymer expert Stanley Backer leads pioneering Textile Information Retrieval Project (TIRP). Sponsored by the US Department of Commerce, TIRP becomes one of the first functional online information retrieval systems, allowing simultaneous access to a database of textile information by up to 25 separate users in seven languages in two continents.

1966:

Professor Robert Mann develops the Boston Arm, demonstrating a naturally controlled cybernetic prosthesis for an amputee.

The device, for the first time, allows an amputee three degrees of freedom in moving objects.



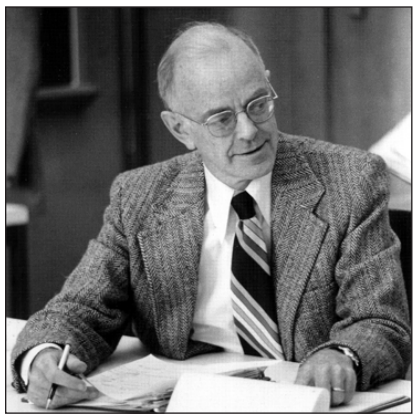
Credit: Mechanical Engineering Archives

1966:

Stephen H. Crandall, Dean C. Karnopp, and Edward F. Kurtz Jr. publish *Dynamics of Mechanical and Electromechanical Systems*.

1966:

Frank McClintock and Ali Argon publish *Mechanical Behavior of Materials*, which uses mechanics to understand the microstructure of materials and how it determines mechanical properties.

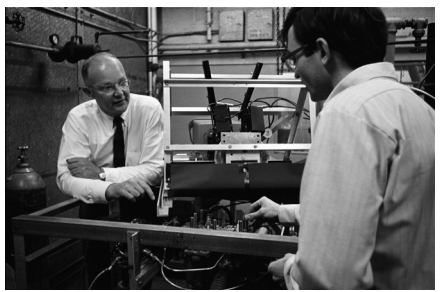


Credit: MIT News Office

1969:

The faculty in the Fluid Mechanics Laboratory transition their research to focus on major societal problems that can be helped by a mechanical engineering approach. Ronald Probstein concentrates on desalination, Jim Keck and Jay Fay on air pollution and combustion engines, and Ascher Shapiro and Forbes Dewey on biomedical research.

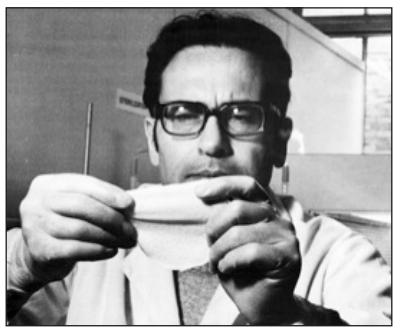
This “reconversion” was viewed at the Institute as a model for resolving concerns with research directions at a time of societal and campus-wide unrest.



Credit: MIT Museum

1969:

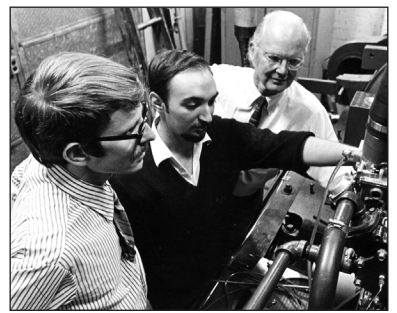
Professor Ioannis Yannas begins developing artificial skin, a synthetic material used to treat burn victims. Its first clinical implementation is in 1981.



Credit: Mechanical Engineering Archives

1969:

MechE's Sloan Automotive Laboratory, an early leader in pollution research, releases the first in an extensive series of reports and papers on improving automotive emissions and efficiency.



Credit: MIT Museum

1970:

Working under the diection of Professor Robert Mann, MIT engineer George Dalrymple designs and builds BrailleEmboss, the world's first Braille embosser, controlled by Mitre Corporation's DOTSYS software.

Credit: MIT Museum

1970:

"Introduction to Design" holds a design contest that becomes an annual robot-building competition. Course 2.70's (later 2.007) experiential, hands-on apprenticeship becomes the department's flagship sophomore subject.

Credit: Mechanical Engineering Archives

1973:

Frank McClintock's trendsetting publications on the physical mechanisms of ductile fracture and fatigue crack propagation opens up a new chapter in the engineering and scientific study of these technologically important phenomena. His pioneering multiscale and multidisciplinary work demonstrated that real understanding of the actual mechanisms of material fracture and degradation on the appropriate microstructural mechanism scale at the tips of cracks enable the design of tougher alloys.

1975:

Ocean Engineering faculty members launch a program on Arctic acoustics leading to such fundamental discoveries as the first proof of Artic Ocean warming.

Credit: AWI

1976:

Ocean Engineering begins its long and fruitful partnership with the Woods Hole Oceanographic Institute.

Credit: Mechanical Engineering Archives

1977:

Credit: MIT Technology Review

The Laboratory for Manufacturing and Productivity (LMP) is established by Professor Nam Suh. LMP research spawns a host of innovations from many faculty, including microcellular foams, 3D printing, RFID technology, and others.

1978:

Thomas Sheridan and William Verplank establish an eight-level taxonomy of human/machine interactions that becomes the basis for understanding how people interact with products and complex systems.

A Scale of Levels of Automation

1. Computer offers no assistance; human must do it all.
2. Computer suggests many alternative ways to do the task.
3. Computer narrows set of alternatives to just a few.
3. Computer recommends one way to do the task.
4. Computer executes that recommendation when and if human approves.
5. Computer allows human a restricted time to veto before automatic execution.
6. Computer chooses a method, executes, and necessarily informs human.
7. Computer chooses a method, executes, and informs human only if requested.
8. Computer chooses a method, executes, and ignores the human.

1979:

Credit: MIT News Office

Professor Jerry Milgram works on the IXTOC oil spill. A long-term outcome includes advances in understanding towing and mooring systems.

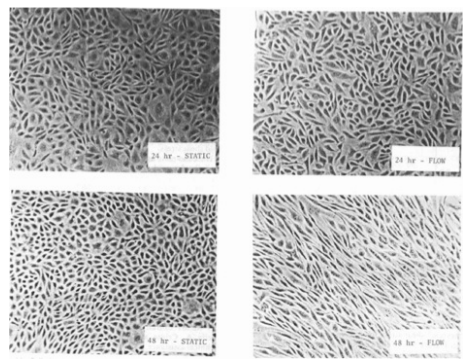
1981:

Ioannis Yannas completes synthesis of the first “artificial skin,” which emulates the regenerative properties of living skin.

Credit: MIT Collections and Archives

1981:

Profossor Forbes Dewey and doctoral candidate Steve Bussolari collaborate with the Gimbrone Lab to perform the very first controlled in vitro experiments with living cells under shear flow. These experiments establish the validity of the culture methods by reproducing features of cellular response known to occur in vivo, and open a new dimension to the study of cardiovascular biology.



Credit: Forbes Dewey

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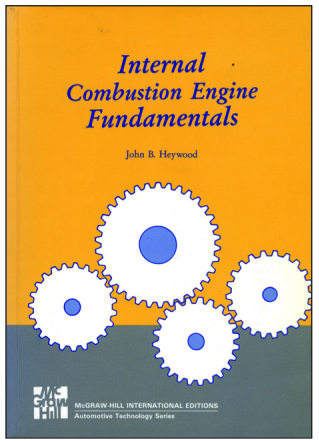
1983:

Professor Emanuel Sachs' "string ribbon" pioneers a novel crystal growth process for producing low-cost solar cells.

1988:

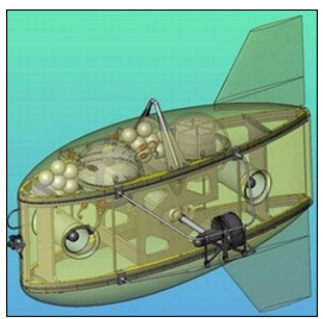


Courtesy: John Heywood

Professor John B. Heywood publishes *Internal Combustion Engine Fundamentals*, which replaces Taylor's *Practice: Volume 1* as the primary textbook in engine design.

1988:

The MIT Sea Grant Autonomous Underwater Vehicle (AUV) Laboratory is established. It makes leading contributions to the commercialization of AUV technology and autonomous ocean sampling networks.



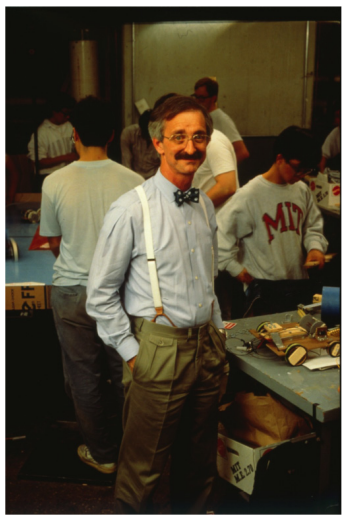
Credit: Mechanical Engineering Archives

1989:

Ely Sachs, with Michael Cima and colleagues, patents the “printing” of three-dimensional objects directly from CAD software by spraying a fluid that binds together layers of powdered material.

Credit: Mechanical Engineering Archives

1990:



Credit: Stanley Rowin

Professor Woodie Flowers hosts “Scientific American Frontiers,” a television program developed to inform the public about new technologies and scientific advances.

1991:

Professor Arthur Baggeroer participates in the Heard Island experiment, during which his team becomes the first to find, identify, and calculate average ocean temperature measurements.

Credit: MIT Research Laboratory of Electronics

1992:

Professor Jerry Milgram is the key technical advisor to Team America[3], led by William I. Koch, which recaptures the America's Cup.

Credit: MIT Museum

1992:

FIRST Robotics Competition is first held, modeled after the sophomore "Introduction to Design" course. By 2010, the contest attracts 45,000 high schoolers from around the world.

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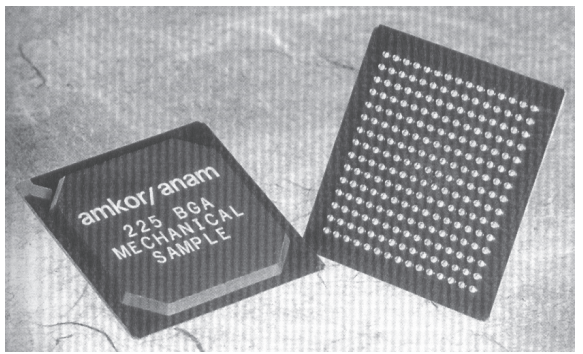
1992:

Credit: MIT News Office

Roger Kamm provides a quantitative description of deep vein thrombosis and, later, of atherosclerotic plaque rapture in arteries. His approach revolutionizes the biomechanical description of vascular disease. The study establishes that stenosis severity is not necessarily the major factor that predisposes the arterial plaque to rupture, as widely believed.

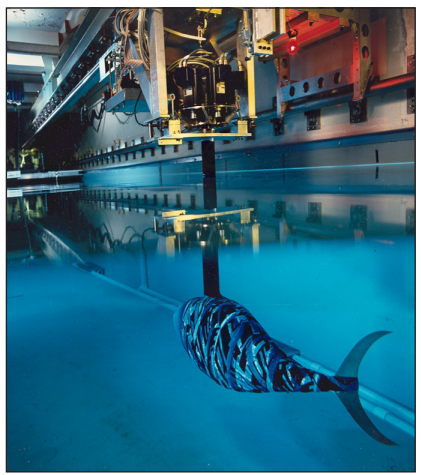
1993:

Employing the concept of continuous jet break-up, Professor Jung-Hoon Chun and his group invent a technology used in producing ball-grid array (BGA) solder balls, which are used world-wide in micro-electronics packaging.



Credit: Jung-Hoon Chun

1995:



Credit: Michael Triantafyllou

The first marine biomimetic robot, developed by Professor Michael Triantafyllou and David Barrett, leads to the identification of scaling laws in fish swimming.

1995:

Major renovation of the student projects workshop, renamed the “Pappalardo Engineering Projects Laboratory,” fills the need for state-of-the-art undergradate laboratory facilities.

Credit: Mechanical Engineering Archives

1996:

A cutting-edge vision of product development matches MechE senior teams with experts on every stage of the process, including customer needs analysis, conceptual design, prototyping, product testing, and market planning.

Credit: MIT News Office

1996:

Sanjay Sarma and David Brock develop the 5cents RFID tag and many of the industry standards and technologies that form the foundation of the use of RFID in supply chain management.

1998:

Peter T. So develops the first noninvasive images of the anatomy of the skin to a depth of 200 microns below the surface.

2001:

Professor John H. Lienhard V publishes “A Heat Transfer Textbook” online for free download. By 2010, a quarter million digital copies are distributed to more than 150 countries and to all seven continents.

2002:

Amy Smith creates D-Lab and challenges students to design simple, affordable devices to address problems in the developing world.

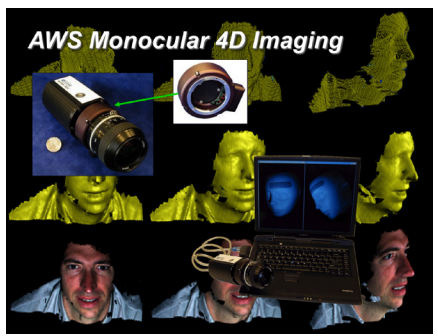
Credit: Amy Smith

2002:

MechE's pioneering flexible engineering degree, Course 2-A, receives accreditation. This customizable degree sees rapid growth in enrollment and begins to be adopted by other departments in 2010.

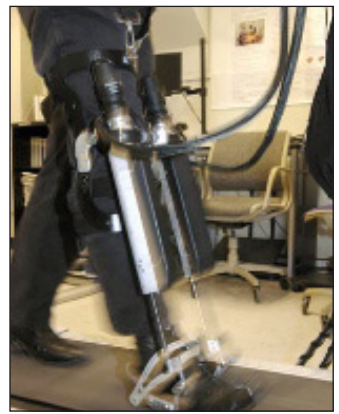
2003:

Professor Douglas Hart develops a method of three-dimensional imaging and image processing, deriving from an optical sensing system for measuring fluid dynamics for three dimensions. It is spun out by Brontes Technologies, a dental imaging technology.



Credit: Mechanical Engineering Archives

2005:

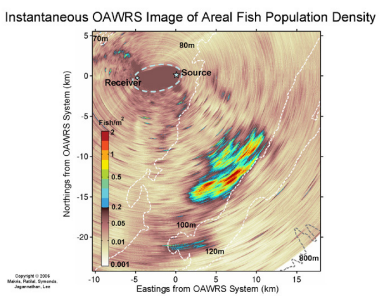


Credit: Mechanical Engineering Archives

MIT researchers announce the creation of the Anklebot, which fits around the leg in a brace to help improve movement of a paralyzed ankle. The device is intended as a tool for patients recovering from a stroke.

2006:

Professor Nicholas Makris and collaborators introduce ocean acoustic waveguide remote sensing (OAWRS), which enables the observation and tracking of massive fish populations in their natural habitat and migratory patterns.



Courtesy Nicholas Makris

2009:

Professors Dan Frey and David Wallace team with others to create and develop the television series “Design Squad.” The show, which airs on PBS, is designed to inspire middle school students to become engineers.

Credit: Public Broadcasting Station

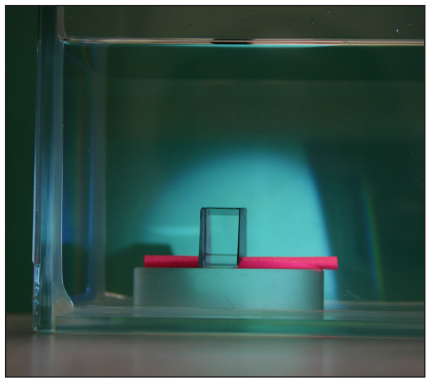
2009:

A team led by Professor Gang Chen announces the first experimental confirmation of the breakdown in Planck's blackbody radiation law when heat is transferred between objects that are nano-distances apart, determining that heat transfer can be 1,000 times greater than the law predicts.

Credit: Mechanical Engineering Archives

2009:

Baile Zhang, Yuan Luo, Xiaogang Larry Liu, and Professor George Barbastathis invent an invisibility cloak made from a crystalline form of calcium carbonate. The cloak works when visible light causes the crystal wedge to appear flat, thus rendering the object underneath it invisible to the human eye and any scientific measurement instrument.



Credit: Baile Zhang and George Barbastathis

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Mechanical Engineering Department Heads

Channing Whittaker, 1873-1883

Gaetano Lanza, 1883-1911

Edward Furber Miller, 1911-1933

Jerome Clark Hunsaker, 1933-1947

Carl Richard Soderberg, 1947-1954

Jacob Peter Den Hartog, 1954-1958

Joseph Henry Keenan, 1958-1961

Horton Guyford Stever, 1961-1965

Ascher Herman Shapiro, 1965-1974

Herbert Heath Richardson, 1974-1962

David N. Wormley, 1982-1991

Nam P. Suh, 1991-2001

Rohan C. Abeyaratne, 2001-2008

Mary Cunningham Boyce, 2008-

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