

DEPARTMENT OF MECHANICAL ENGINEERING

Research Laboratories and Programs

The Mechanical Engineering Department is organized into seven areas that collectively capture the broad range of interests and activities within it. These areas are:

- Mechanics: Modeling, Experimentation, and Computation (MMEC)
- Design, Manufacturing, and Product Development
- Controls, Instrumentation, and Robotics
- Energy Science and Engineering
- Ocean Science and Engineering
- Bioengineering
- Nano/Micro Science and Technology

The educational opportunities offered to students in mechanical engineering are enhanced by the availability of a wide variety of research laboratories and programs, and well-equipped shops and computer facilities.

The department provides many opportunities for undergraduates to establish a close relationship with faculty members and their research groups. Students interested in project work are encouraged to consult their faculty advisor or approach other members of the faculty.

Many members of the Department of Mechanical Engineering participate in interdepartmental or school-wide research activities. These include the Center for Biomedical Engineering, Center for Computational Science and Engineering, Computational and Systems Biology Program, Computer Science and Artificial Intelligence Laboratory, Institute for Soldier Nanotechnologies, Laboratory for Manufacturing and Productivity, Materials Research Science and Engineering Center, MIT Energy Initiative, Operations Research Center, Program in Polymers and Soft Matter, and Sea Grant College Program. Detailed information about many of these can be found under Research and Study and Interdisciplinary Graduate Programs. The department also hosts a number of industrial consortia, which support some laboratories and research projects. Research in the department is supported, in addition, by a broad range of federal agencies and foundations.

A partial list of departmental laboratories, listed according to the seven core areas of research, follows.

Mechanics: Modeling, Experimentation, and Computation

AMP Mechanical Behavior of Materials Laboratory

Mechanisms of deformation and fracture processes in engineering materials.

Center for Nonlinear Science

Interdisciplinary research into nonlinear phenomena. Incorporates the Nonlinear Dynamical Systems Lab (modeling, simulation, analysis), Nonlinear Dynamics Lab (experiments), and Nonlinear Systems Lab.

Composite Materials and Nondestructive Evaluation Laboratory

Development of quantitative nondestructive evaluation characterizations which are directly correlatable with the mechanical properties of materials and structures.

Finite Element Research Group

Computational procedures for the solution of problems in structural, solid, and fluid mechanics.

Hatsopoulos Microfluids Laboratory

Fundamental research on the behavior of complex fluid systems at microscopic scales, and associated engineering applications.

Design, Manufacturing, and Product Development

Auto-ID Laboratory

Creation of the "Internet of Things" using radio frequency identification and wireless sensor networks, and of a global system for tracking goods using a single numbering system called the Electronic Product Code.

Computer-Aided Design Laboratory

Advancing the state of the art in design methodology and computer-aided design methods.

Laboratory for Manufacturing and Productivity

An interdepartmental laboratory in the School of Engineering. Polymer microfabrication for microfluidic devices, chemical mechanical planarization for the semiconductor industry, precision macro- and micro-scale devices, and novel metrology methods for micro-scale devices. Small-scale fuel cells design, photovoltaic material and process research, and manufacture of photovoltaic panels. Identification technologies such as RFID, wireless sensors, and complex systems. Methods to integrate data and models across global networks. Factory-level manufacturing systems design and control, and supply chain design and management. Environmentally benign manufacturing.

Martin Center for Engineering Design

Design methodology, design of integrated electrical-mechanical systems, prototype development, advanced computer-aided design techniques.

Park Center for Complex Systems

Research to understand complexity, educating students and scholars on complexity, designing complex systems for the benefit

of humankind, and disseminating knowledge on complexity to the world at large.

Precision Engineering Laboratory

Fundamental and applied research on all aspects of the design, manufacture, and control of high precision machines ranging from manufacturing machines to precision consumer products.

Precision Systems Design and Manufacturing Laboratory

Modeling, design, and manufacturing methods for nanopositioning equipment, carbon nanotube-based mechanisms and machines, and compliant mechanisms.

Controls, Instrumentation, and Robotics

d'Arbeloff Laboratory for Information Systems and Technology

Research on mechatronics, home and health automation, interface between hardware and software, and development of sensing technologies.

Field and Space Robotics Laboratory

Fundamental physics of robotic systems for unstructured environments. Development, design, and prototyping of control and planning algorithms for robotic applications, including space exploration, rough terrains, sea systems, and medical devices and systems.

Nonlinear Systems Laboratory

Analysis and control of nonlinear physical systems with emphasis on adaptation and learning in robots.

Energy Science and Engineering

Center for Energy and Propulsion Research

Innovative science and technology for a sustainable energy future in a carbon-constrained world. Fundamental and applied research in energy conversion and transportation, with applications to low-carbon efficient energy and propulsion systems. Includes several research groups:

- *Electrochemical Energy Laboratory*. Engineering of advanced materials for lithium batteries, proton exchange membrane and solid oxide fuel cells, and air battery and fuel cell hybrids.
- *Reacting Gas Dynamics Laboratory*. Fluid flow, chemical reaction, and combustion phenomena associated with energy conversion in propulsion systems, power generation, industrial processes, and fires.
- *Sloan Automotive Laboratory*. Processes and technology that control the performance, efficiency, and environmental impact of internal combustion engines, their lubrication, and fuel requirements.

Cryogenic Engineering Laboratory

Application of thermodynamics, heat transfer, and mechanical design to cryogenic processes and instrumentation and the operation of a liquid helium facility.

Rohsenow Kendall Heat Transfer Laboratory

Fundamental research in microscale/nanoscale transport, convection, laser/material interaction, and high heat fluxes; applied research in water purification, thermoelectric devices, energy-efficient buildings, and thermal management of electronics.

Ocean Science and Engineering

Center for Ocean Engineering

Provides an enduring ocean engineering identity, giving visibility to the outside world of MIT's commitment to the oceans, and serves as the focus point of ocean-related research at the Institute. Supports the research activities of the MIT-WHOI Joint Program in Oceanographic Engineering and the Naval Construction and Engineering Program. Encompasses the activities of the following research groups and laboratories:

- *Autonomous Marine Sensing Lab*. Distributed ocean sensing concepts for oceanographic science, national defense, and coastal management and protection. Oceanographic sensing and modeling, sonar system technology, computational underwater acoustics, and marine robotics and communication networking.
- *Design Lab*. Ship design, offshore structure design, marine robotics, geometric and solid modeling, advanced manufacturing, and shipbuilding. Includes the Center for Environmental Sensing and Modeling.
- *Experimental Hydrodynamics Lab*. Advanced surface ship, offshore platform, and underwater vehicle design. Development of non-invasive flow measurement and visualization methods.
- *Impact and Crashworthiness Laboratory*. Industry-oriented fracture testing and prediction technology of advanced high-strength steel sheets for automotive and shipbuilding applications. Includes both quasi-static and high strain rate response and effect of loading history on fracture.
- *Experimental and Nonlinear Dynamics Lab*. Laboratory experiments to obtain insight into all manner of dynamical phenomena, from micro-scale diffusive processes to global-scale oceanic wave fields. Field studies for ocean-related problems.
- *Laboratory for Ship and Platform Flows*. Modeling of free surface flows past conventional and high-speed vessels and estimation of their resistance and seakeeping in deep and shallow waters. Analytical and computational techniques.
- *Laboratory for Undersea Remote Sensing*. Ocean exploration, undersea remote sensing of marine life and geophysical phenomena, wave propagation and scattering theory in remote sensing, statistical estimation and information theory, acoustics and seismics, Europa exploration.

- *Marine Hydrodynamics Laboratory (Propeller Tunnel)*. A variable-pressure recirculating water tunnel capable of speeds up to 10 m/s. Experiments are performed using state-of-the-art measurement techniques and instrumentation.
- *Multidisciplinary Ocean Dynamics and Engineering Laboratory*. Complex physical and interdisciplinary oceanic dynamics and processes. Mathematical model and computation methods for ocean predictions, dynamical diagnostics, and for data assimilation and data-model comparisons.
- *Ocean Engineering Testing Tank*. The tank is 108 feet long, 8.5 feet wide, with an average depth of 4.5 feet. The wave generator can generate harmonic or random waves. The tank also houses several laser flow visualization systems.
- *Vortical Flow Research Laboratory*. Advanced capabilities for simulation of complex vertical flows. Powerful computer workstations and LINUX clusters, computer-video image conversion, and state-of-the-art flow simulation animation technologies.
- *MIT Sea Grant AUV Lab*. Dedicated to autonomous underwater vehicles (AUVs), the lab is a leading developer of advanced unmanned marine robots, with applications in oceanography, environmental monitoring, and underwater resource studies. It engages in instrumentation and algorithm development for underwater vehicles performing navigation- and information-intensive tasks. Various vehicle platforms, and fabrication tools and materials are available.

Bioengineering

Bioinstrumentation Laboratory

Utilization of biology, optics, mechanics, mathematics, electronics, and chemistry to develop innovative instruments for the analysis of biological processes and new devices for the treatment and diagnosis of disease.

Human and Machine Haptics

Interdisciplinary studies aimed at understanding human haptics, developing machine haptics, and enhancing human-machine interactions in virtual reality and teleoperator systems.

Laboratory for Biomechanics of Cells and Biomolecules

Development of new instruments for the measurement of mechanical properties on the scale of a single cell or single molecule to better understand the interactions between biology and mechanics.

Newman Laboratory for Biomechanics and Human Rehabilitation

Research on bioinstrumentation, neuromuscular control, and technology for diagnosis and remediation of disabilities.

Nano/Micro Science and Technology

Pappalardo Laboratory for Micro/Nano Engineering

Creation of new engineering knowledge and products on the nano and micro scale through multidomain, multidisciplinary, and multiscale research.