MECHANICAL ENGINEERING

Director of undergraduate studies: Corey O’Hern (corey.ohern@yale.edu), M203 ML, 432-4258; seas.yale.edu/departments/mechanical-engineering-and-materials-science

Mechanical engineering is among the most diversified of the traditional engineering disciplines. The mechanical engineer builds machines to extend our physical and mental capabilities and to convert traditional and novel energy sources into useful forms.

The role of the mechanical engineer has changed dramatically over the past few decades with the extensive use of high-performance computers (in such areas as computational fluid dynamics, materials design, control, and manufacturing), the interfacing of microelectromechanical systems and actuators via microprocessors to build high-precision sensors and devices, and the advent of advanced materials (e.g., composites, shape-memory alloys, ceramics, and superconductors) for new applications (e.g., coatings, biomaterials, and computer storage). These areas offer mechanical engineering students special opportunities for creativity, demanding that they learn not only in depth but also in breadth. Demands for increased energy efficiency and reduced environmental impact—as might be realized, for example, in novel gas turbine or electric hybrid vehicles—require that students understand the fundamentals of mechanics, thermodynamics, fluid mechanics, combustion, and materials science. In all these tasks, the utmost consideration of the modern mechanical engineer is improving the quality of human life. The engineer must also be constantly aware both of the finiteness of Earth’s resources and its environment and of the burden that engineering places on them.

The educational mission of the Department of Mechanical Engineering and Materials Science is to provide an excellent education that will prepare students to become members of the next generation of mechanical engineers. To implement this mission, the department adheres to the following set of educational objectives: to provide a balanced technical and nontechnical education to enable graduates to enter highly selective graduate schools and/or to pursue technical careers in industry or government laboratories; to enable graduates to improve and adapt their skills to accommodate rapid technological changes; to prepare graduates to communicate effectively and to understand the ethical responsibilities and impact on society of their profession. To achieve these objectives, the following fundamental educational goals have been established for the Department of Mechanical Engineering and Materials Science: to provide a comprehensive introduction to basic science and mathematics, which form the foundation of mechanical engineering; to provide thorough training in analytical and experimental methods and in data analysis, including problem formulation; to provide instruction in the fundamentals of the design process, including project innovation, synthesis, and management, both individually and in a team setting; to provide both a technical and a nontechnical program of study in which oral and written communication skills are developed; and to instill in students an understanding of their professional and ethical responsibilities, which affect society and their profession.

COURSES FOR NONMAJORS

Mechanics and mechanical engineering content can be found in several courses intended for those not majoring in science. See Engineering and Applied Science.

THE MECHANICAL ENGINEERING PROGRAM

At Yale, three mechanical engineering programs are offered: a B.S. degree program with a major in Mechanical Engineering, a B.S. degree program with a major in Engineering Sciences (Mechanical), and a B.A. degree program with a major in Engineering Sciences (Mechanical). Prospective majors in both B.S. programs are advised to complete introductory physics and mathematics through calculus (MATH 115) by the end of their first year.

A student’s undergraduate engineering program may include one or more special project courses (MENG 471, 472, 473, or 474), in which the student pursues a particular research interest through design-oriented projects and experimental investigations. Projects may be initiated by the student, may be performed in a team, or may be derived from the ideas of faculty members who place undergraduates in their ongoing research projects. All interested students should contact the director of undergraduate studies (DUS) for more information on special project courses.

B.S. degree program in Mechanical Engineering This is the most technically intensive mechanical engineering degree program and is accredited by the Engineering Accreditation Commission of ABET, Inc. This program is appropriate for students who plan careers as practicing engineers in industry, consulting firms, or government, as well as for students who are considering a career in research and plan to pursue an advanced degree in engineering.

B.S. degree program in Engineering Sciences (Mechanical) This non-ABET degree program is suitable for students who wish to gain significant expertise within mechanical engineering while combining their engineering studies with related disciplines. For example, a number of students have taken courses in architecture while pursuing a program in mechanical engineering that emphasizes structural mechanics; similarly, a student with an interest in computer graphics might combine engineering courses in computer-aided design with programming courses from the Department of Computer Science.

B.A. degree program in Engineering Sciences (Mechanical) In a society with increasing levels of technical sophistication, a well-rounded individual must have some background in science and technology. The non-ABET B.A. program is designed for students who may be planning careers in business, law, economics, medicine, journalism, or politics but need to understand the impact that science and technology can have on society at large. An understanding of engineering methods and practices, combined with a traditional liberal
arts education, provides a strong background for a variety of careers. The program is well suited for students who wish to fulfill the requirements of two majors.

The major for all three degree programs requires a group of prerequisites or equivalents; several courses beyond the prerequisites; and a senior requirement, as indicated below.

PREREQUISITES

B.S. degree program in Mechanical Engineering

**Prerequisites for the Class of 2023** Students may follow the prerequisites that were in place when they declared their major.

**Prerequisites for the Class of 2024 and beyond** The prerequisites in mathematics are MATH 112, 115, and ENAS 151, or the equivalent. The basic science prerequisites are PHYS 180, 181, or 200, 201; one laboratory from PHYS 165L or 205L, and one from PHYS 166L or 206L, or equivalents, and one introductory lecture course in chemistry, numbered CHEM 161 or higher. The chemistry lecture course may be waived for a Chemistry AP score of 4 or 5 or an IB Higher level or Standard level score of 6 or 7.

B.S. degree program in Engineering Sciences (Mechanical) The prerequisites in mathematics are MATH 112, 115, and ENAS 151, or the equivalent. The basic science prerequisites are PHYS 180, 181, or 200, 201; one laboratory from PHYS 165L or 205L, and one from PHYS 166L, 206L, or MENG 286L.

B.A. degree program in Engineering Sciences (Mechanical) The prerequisites in mathematics are MATH 112 and 115. The basic science prerequisite is physics at least to the level of PHYS 170, 171.

REQUIREMENTS OF THE MAJOR

B.S. degree program in Mechanical Engineering requires 20 courses and 19 credits beyond the prerequisites as follows:

**Requirements for the Class of 2023** If not taken as a prerequisite, one lecture course in chemistry numbered CHEM 161 or higher is required, as well as the requirements listed below. The chemistry lecture requirement may be waived for a Chemistry AP score of 4 or 5 or an IB Higher level or Standard level score of 6 or 7.

**Requirements for the Class of 2024 and beyond**

1. Advanced mathematics: ENAS 194 and MATH 222 or 225
2. Mechanical engineering and related: MENG 185, 211, 280, 285, 286L, 325, 361, 363L, 383, 389, 390, MENG 471 and MENG 488L (the senior requirement), ENAS 130, EENG 200
3. Technical electives: three approved technical electives chosen in consultation with the DUS; only one course from MENG 471, 472, 473, or 474 may be counted as one of the three technical electives.

The curriculum in this program is arranged in prescribed patterns, but some departures from it are possible with approval of the DUS.

B.S. degree program in Engineering Sciences (Mechanical) The major requires twelve approved term courses in engineering (with only one course from MENG 471, 472, 473, or 474), beyond the prerequisites and including the senior project, which can cover a broad array of topics within the subject, provided that they contribute to a coherent program. Students should consult with the DUS at the beginning of their sophomore year.

B.A. degree program in Engineering Sciences (Mechanical) The program requires eight approved term courses in engineering (with only one course from MENG 471, 472, 473, or 474), beyond the prerequisites, including the senior project. Students should consult with the DUS at the beginning of their sophomore year.

Credit/D/Fail No courses taken Credit/D/Fail may be counted toward the Mechanical Engineering major, including prerequisites.

Roadmap See visual roadmap of the requirements.

SENIOR REQUIREMENT

B.S. degree program in Mechanical Engineering Students satisfy the senior requirement by taking MENG 487L (full-credit) and MENG 488L (half-credit) in the senior year.

B.S. degree program in Engineering Sciences (Mechanical) Students satisfy the senior project requirement by completing MENG 404; MENG 471, 472, 473, or 474; or another upper-level design course (taken during the senior year) chosen in consultation with the DUS. Only one course from MENG 471–474 may be counted toward the requirements of the major.

B.A. degree program in Engineering Sciences (Mechanical) Students satisfy the senior project requirement by completing MENG 471, 472, 473, or 474; or another upper-level design course (taken during their senior year) chosen in consultation with the DUS. Only one course from MENG 471–474 may be counted toward the requirements of the major.

REQUIREMENTS OF THE MAJOR

MECHANICAL ENGINEERING, B.S.
Mechanical Engineering

Prerequisites MATH 112, 115, and ENAS 151, or equivalent; PHYS 180, 181, or 200, 201, and 2 labs (1 from PHYS 165L or 205L; 1 from PHYS 166L or 206L, or equivalents), and 1 introductory chemistry lecture course

Number of courses 20 term courses and 19 credits beyond prerequisites (including senior req)

Specific courses required ENAS 130 and 194; EENG 200; MATH 222 or 225; MENG 185, 211, 280, 285, 286L, 325, 361, 363L, 383, 389, 390

Distribution of courses 3 technical electives chosen in consultation with DUS (only one of MENG 471, 472, 473, or 474)

Substitution permitted With DUS approval

Senior requirement MENG 487L and MENG 488L taken in senior year

ENGINEERING SCIENCES (MECHANICAL), B.S.

Prerequisites MATH 112, 115, and ENAS 151, or equivalent; PHYS 180, 181, or 200, 201, and 2 labs (1 from PHYS 165L or 205L; 1 from PHYS 166L, 206L, or MENG 286L)

Number of courses 12 term courses beyond prerequisites (incl senior req)

Substitution permitted With DUS approval

Senior requirement MENG 404; MENG 471, 472, 473, or 474; or another upper-level design course chosen in consultation with the DUS

ENGINEERING SCIENCES (MECHANICAL), B.A.

Prerequisites MATH 112, 115; PHYS 170, 171 or higher

Number of courses 8 term courses beyond prerequisites (incl senior req)

Substitution permitted With DUS approval

Senior requirement MENG 471, 472, 473, or 474; or another upper-level design course chosen in consultation with the DUS

Mechanical engineering is among the most diversified of the traditional engineering disciplines. Mechanical engineers build machines to extend our physical capabilities, develop techniques to efficiently convert existing and novel energy sources into useful forms, and design functional materials with targeted properties.

The role of the mechanical engineer has changed dramatically in recent decades with the extensive use of large-scale computing, nanoscale sensors and actuators, and novel materials (e.g., carbon nanotubes, biologically inspired materials, and metamaterials). Demands for increased energy efficiency, enhanced performance of materials on smaller length scales and faster timescales, and reduced environmental impact require that students understand the fundamentals of mechanics, thermodynamics, fluid mechanics, and materials science.

In all these tasks, the utmost consideration of the modern mechanical engineer is improving the quality of human life. Engineers must be constantly aware both of the finiteness of Earth’s resources and of the impact of progress in science and engineering on the environment.

The program in Mechanical Engineering provides a broad education in the foundations of the disciplines mentioned above and prepares students both for graduate studies in these areas and for entry into appropriate positions in research laboratories, industry, or government.

Mechanical Engineering offers three degree programs. The B.S. in Mechanical Engineering is the most intensive program and is accredited by the Engineering Accreditation Commission of ABET, Inc. The B.S. in Engineering Sciences (Mechanical) requires fewer courses, but also allows greater flexibility. Students seeking a strong background in mechanical engineering along with the opportunity to take additional courses in other scientific and engineering disciplines, the liberal arts, or social sciences should choose this program. The B.A. in Engineering Sciences (Mechanical) is less intensive. It is appropriate for students who would like some background in mechanical engineering but whose career plans lie in other fields, such as law, medicine, or business.

Prospective majors should take MATH 112, MATH 115, and ENAS 151, or the equivalent; two terms of PHYS 180, 181, or PHYS 200, 201; two terms of physics laboratory (PHYS 165L, 166L or PHYS 205L, 206L), and an introductory chemistry lecture. The sequence PHYS 170, 171 without a laboratory is acceptable for the B.A. degree.

Further details of the program can be found on the department website. The director of undergraduate studies (DUS) welcomes consultation with students about their program of study at any time.

FACULTY OF THE DEPARTMENT OF MECHANICAL ENGINEERING AND MATERIALS SCIENCE

Professors Charles Ahn, Ira Bernstein (Emeritus), Aaron Dollar, Juan Fernández de la Mora, Alessandro Gomez, †Sohrab Ismail-Beigi, †Shun-Ichiro Karato, Marshall Long (Emeritus), Corey O’Hern, †Vidvuds Ozolins, †Brian Scassellati, Jan Schroers, Udo Schwarz (Chair), Mitchell Smooke

Associate Professors Rebecca Kramer-Bottiglio, Madhusudhan Venkadesan

Assistant Professors Ian Abraham, Amir Pahlavan, Diana Qiu, †Daniel Wiznia

Senior Lecturer Beth Anne Bennett

Lecturers Joran Booth, Lawrence Wilen, Joseph Zinter

†A joint appointment with primary affiliation in another department or school.

View Courses
Courses

* MENG 450b / APHY 450b / ENAS 450b, Advanced Synchrotron Techniques and Electron Spectroscopy of Materials  Charles Ahn
Introduction to concepts of advanced x-ray and electron-based techniques used for understanding the electronic, structural, and chemical behavior of materials. Students learn from world-leading experts on fundamentals and practical applications of various diffraction, spectroscopy, and microscopy methods. Course highlights the use of synchrotrons in practical experiments. Prerequisites: physics and quantum mechanics/physical chemistry courses for physical science and engineering majors, or by permission of instructor.  QR, SC