Department of Mechanical Engineering

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General Overview

Mechanical engineers design, analyze, and manufacture new products and technologies. They address society's needs through a combination of mechanical engineering fundamentals and innovative ideas. Our curriculum emphasizes engineering theory, hands-on experience and technical skills. Our students learn how to solve practical problems and analyze situations by converting concepts into reliable and cost-effective devices and processes.

Mechanical engineers work in a variety of sectors: small start-up companies, multi-national corporations, government agencies, national laboratories, consulting firms, and universities. Specializing in research, design, manufacturing, or management, they design and implement devices that affect our daily lives. Examples include:

- Jet Engines
- Automobiles
- Aircraft and Spacecraft
- Acceleration and Pressure Sensors
- Heating, Ventilating, and Air Conditioning Systems
- Power Generations Systems
- Energy Storage Devices
- Biomedical and Biomechanical Devices (such as artificial hip implants)
- Mechanical and Electronic Systems (such as robots)

Through our curriculum, students receive a solid scientific foundation from the start. During their first year, students take courses in mathematics, physics, computer programming, and chemistry. In addition, students take two introductory engineering courses which expose them to the different engineering departments. Our mechanical engineering introductory course is project-oriented, and students learn about the various disciplines of mechanical engineering through lectures, laboratories, and hands-on projects.

In their sophomore and junior years, students take core engineering courses to develop strong engineering fundamentals. These course topics include:

- Solid and Fluid Mechanics
- Thermodynamics
- Heat Transfer
- Dynamics
- Systems and Controls
- Design Methods and Skills
- Experimentation and Numerical Methods

During their senior year, students complete a capstone course in engineering design. In this course, students work on teams to develop prototype hardware for new products. These projects expose students to the design process, from concept to product, and emphasize effective communication and presentations skills. Past design projects include:

- water purification and transportation solution
- smart shutters
- rehabilitative knee brace
- interactive kickboxing target
- phone image stabilizing case

Additionally, students can utilize our flexible elective structure to pursue individual interests. We recognize the broad role mechanical engineers play in society as leaders in business, government, and law. Therefore, we offer elective options that enable students to:

- begin taking elective courses during their sophomore year
- specialize in a particular area of mechanical engineering
- emphasize a technical area within another engineering or science department
- pursue interests in another Carnegie Mellon department (such as foreign language, design, music, or business) to earn a double major or minor

We offer advanced courses that students can choose as electives, depending on their interests. Electives include:

- energy and environment
- controls
- vibrations
- dynamics
- manufacturing
- robotics
- internal combustion engines
- mechatronics
- fluid and solid mechanics
- engineering design
- computation engineering
- additive manufacturing
- project management
- product design
- bioengineering

As mentioned, students can also take technical and non-technical electives from other Carnegie Mellon departments. Students can use these courses to pursue a double major or minor, or develop an individual concentration with a faculty advisor.

Students can also tailor their undergraduate experiences through study abroad, research, cooperative education or the Integrated Master's/Bachelor's Program. In today's global society, a study abroad experience is crucial and should serve as an integral part of an undergraduate engineering education. An academic experience abroad is encouraged and assistance provided for course choices, but students may also participate in research, complete an internship, or partake in an international service-learning engineering project abroad. Exceptional students are eligible to participate in departmental or college senior honors research under faculty supervision. In the Integrated Master's/Bachelor's program, students take graduate courses during their senior year, accumulating credit toward their Master's degrees. Students can then complete all the requirements for the M.S. degree (course-work option) in the fall following their B.S. degree.

Students use the latest computer-based design and analysis methods for their courses and project work, including industry-standard design tools aided by computers. We provide an undergraduate computer lab where students can complete design work, structural analyses, thermal/fluid finite element analyses, and dynamic system simulations. Using these computer tools, students can visualize a product's performance before they fabricate it.

We also provide students with a variety of resources including MIG welding, rapid prototyping, and a fully equipped student shop (includes lathes, drill presses, milling machines, band saws, and other hand and power tools). Our Thermal Fluids and Mechanical Systems laboratories contain state of-the-art experimentation hardware and software.
Our faculty performs research sponsored by industry and government agencies. Faculty often use the results of their research as specific examples, case studies, and projects in undergraduate courses, allowing students to see firsthand the recent advances in mechanical engineering.

We also sponsor frequent seminars and invite nationally and internationally reputed speakers to give lectures. We encourage all students to attend these seminars to learn about broad perspectives on mechanical engineering.

Educational Objectives

According to ABET (http://www.abet.org/) which evaluates applied science, computing, engineering and technology programs for accreditation, "program educational objectives are broad statements that describe what graduates are expected to attain within a few years of graduation." In view of this definition, the Mechanical Engineering program at Carnegie Mellon has the two following program educational objectives:

- Graduates distinguish themselves as innovative problem solvers and leaders in multidisciplinary settings, making use of a high quality and rigorous technical education that is enriched by a flexible curriculum and interdisciplinary research opportunities.
- Graduates excel in diverse career paths in either the engineering profession or an alternative field, or succeed in graduate studies.

The undergraduate curriculum in the Department of Mechanical Engineering offers students significant opportunities to pursue directions of personal interest, including minors, double majors, participation in research projects, and study abroad. Design and teamwork experiences occur at regular

intervals in the curriculum, and graduates have significant hands-on experience through laboratories and projects. The faculty of the Department has endorsed the following set of skills, or outcomes that graduates of the program are expected to have:

A. an ability to apply knowledge of mathematics, science, and engineering

B. an ability to design and conduct experiments, as well as to analyze and interpret data

C. an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability

D. an ability to function on multidisciplinary teams

E. an ability to identify, formulate, and solve engineering problem

F. an understanding of professional and ethical responsibility

G. an ability to communicate effectively

H. the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context

I. a recognition of the need for, and an ability to engage in lifelong learning

J. a knowledge of contemporary issues

K. an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice

The Mechanical Engineering program is accredited by the Engineering Accreditation Commission of ABET,http://www.abet.org.

Curriculum

The following template outlines the four-year B.S. program through the standard and recommended course sequence. To ensure that prerequisites are completed and to prevent scheduling conflicts, students should discuss any changes to this sequence with their department academic advisor.

Freshman Year

Fall		Units
21-120	Differential and Integral Calculus	10
24-101	Fundamentals of Mechanical Engineering	12
33-141	Physics I for Engineering Students	12
99-101	Computing @ Carnegie Mellon	3
76-101	Interpretation and Argument	9
		46

Spring		Units
21-122	Integration and Approximation	10
xx-xxx	Second Introductory Engineering Course	12
xx-xxx	Restricted Technical Elective 10-13	10
xx-xxx	General Education Course	9
		41

Sophomore Year

Fall		Units
21-259	Calculus in Three Dimensions	9
24-221	Thermodynamics I	10
24-261	Statics	10
xx-xxx	Restricted Technical Elective 10-13	13
xx-xxx	General Education Course	9
24-200	Machine Shop Practice *Required sophomore year*	1
39-210	Experiential Learning I	0
		52

Spring		Units
21-260	Differential Equations	9
24-231	Fluid Mechanics	10
24-262	Stress Analysis	12
xx-xxx	Restricted Technical Elective 10-13	12
xx-xxx	General Education Course	9
24-202	Introduction to Computer Aided Design *Required sophomore year*	1
39-220	Experiential Learning II	0
		53

Junior Year

Fall		Units
24-302	Mechanical Engineering Seminar I- taken either fall or spring	2
24-322	Heat Transfer	10
24-370	Engineering Design I: Methods and Skills	12
24-351	Dynamics	10
36-220	Engineering Statistics and Quality Control	9
xx-xxx	General Education Course	9
39-310	Experiential Learning III	0
		52

Spring		Units
24-321	Thermal-Fluids Experimentation	12
24-311	Numerical Methods	12
24-352	Dynamic Systems and Controls	12
xx-xxx	General Education Course	9
		45

Senior Year

Fall		Units
24-441	Engineering Design II: Conceptualization and Realization- required either fall or spring; alternate with xx-xxx 9 unit elective	12
24-452	Mechanical Systems Experimentation	9
xx-xxx	Elective	9
xx-xxx	Elective	9
xx-xxx	General Education Course	9
		48

Spring		Units
24-441	Engineering Design II: Conceptualization and Realization OR xx-xxx Elective	12
24-xxx	Mechanical Engineering Technical Elective	9-12
xx-xxx	Elective	9
xx-xxx	Elective	9
xx-xxx	General Education Course	9
		48-51

Notes on the Curriculum

1. Students need a minimum of 382 units to complete the B.S. degree.

2. During the first year, students complete24-101 Fundamentals of Mechanical Engineering and another introductory engineering course. If students did not take 24-101 during their first year, they should take 24-101 during their fall semester of their sophomore year in place of the General Education Course. They can then replace that General Education Course in their junior or senior years.

3. Students must pass the following three courses before they begin the core Mechanical Engineering courses in the fall of their sophomore year:
21-120 Differential and Integral Calculus (10 units)
21-122 Integration and Approximation (10 units)
33-141 Physics I for Engineering Students (12 units)*
*33-141 / 33-142 is the recommended sequence for engineering students, although 33-151 / 33-152 would also meet the CIT Physics requirement.

All mathematics (21-xxx) courses required* for the engineering degree taken at Carnegie Mellon must have a minimum grade of C in order to be counted toward the graduation requirement for the BS engineering degree.

A minimum grade of C must be achieved in any required mathematics (21-xxx) course that is a pre-requisite for the next higher level required mathematics (21-xxx) course.

Mechanical engineering undergraduates must satisfy a Science Laboratory requirement to graduate. Normally the Science Laboratory requirement is satisfied by passing 09-101 Introduction to Experimental Chemistry (3

units). Students can also satisfy the Science Laboratory requirement by passing one of the following courses:

03-124	Modern Biology Laboratory	9
33-100	Basic Experimental Physics	6
33-104	Experimental Physics	9
42-203	Biomedical Engineering Laboratory	9

These courses may have prerequisites and tight enrollment limits that students should consider in their planning.

4. Students are required to complete36-220 Engineering Statistics and Quality Control, which may be scheduled in any semester. The sequence of calculus courses (21-120 , 21-122 , 21-259) and 21-260 Differential Equations, should be scheduled as indicated due to Mechanical Engineering Core class prerequisites.

5. The communications requirement can be satisfied by completing at least one of the following options:

		Units
24-302	Mechanical Engineering Seminar I- either fall or spring	2
70-340	Business Communications	9
76-270	Writing for the Professions	9

6. Students must enroll in 24-452 Mechanical Systems Experimentation in the fall of their senior year.
7. 24-441 Engineering Design II: Conceptualization and Realization may be taken in either fall or spring of senior year.

Restricted Technical Electives

Students should have the following courses completed by the end of their sophomore year. These courses are listed as “Restricted Technical Electives” in the example course sequence. Students do have some flexibility in how they sequence these courses during their freshman and sophomore years:

09-101	Introduction to Experimental Chemistry	3
33-142	Physics II for Engineering and Physics Students	12
09-105	Introduction to Modern Chemistry I	10
15-110	Principles of Computing	10

Mechanical Engineering Technical Electives

We require students to take at least one elective labeled as “Mechanical Engineering Technical Elective” in the example course sequence. Students must take at least one non-core 24-xxx course (9-unit minimum) to fulfill the technical elective requirement. Options include:

Design and Manufacturing

24-341	Manufacturing Sciences	9
24-650	Applied Finite Element Analysis	12
24-651	Material Selection for Mechanical Engineers	12
24-674	Design of Biomechatronic Systems for Humans	12
24-681	Computer-Aided Design	12
24-683	Design for Manufacture and the Environment	12
24-688	Introduction to CAD and CAE Tools	12

Mechanical Systems

24-354	Special Topics: Gadgetry: Sensors, Actuators, and Processors	9
24-355	Kinematics and Dynamics of Mechanisms	9
24-451	Feedback Control Systems	12
24-655	Cellular Biomechanics	9
24-657	Molecular Biomechanics	9

Thermal-Fluid Systems

24-421	Internal Combustion Engines	12
24-424	Energy and the Environment	9
24-425	Combustion and Air Pollution Control	9
24-615	Microfluidics	12
24-623	Molecular Simulation of Materials	12
24-642	Fuel Cell Systems	12

We regularly offer these courses and/or new options according to our teaching schedule. However we cannot guarantee to offer a particular course in a given semester.

Students can also take certain mechanical engineering graduate courses to fulfill the technical elective requirement. However, students must have the appropriate prerequisites and the instructor must approve taking the course. Students can find a list of graduate courses we offer on our website.

Students cannot use the research or project courses to fulfill the technical elective requirement. However, they can use these courses to fill the remaining five elective slots. Courses that do not fulfill the technical elective requirements are:

24-391/ 24-392 Mechancial Engineering Project
24-491/ 24-492 Department Research Honors
39-xxx CIT series courses

Electives

Students must first complete five elective courses, as indicated in the example course sequence. Students can take either technical or non-technical courses to fill these five slots from either the mechanical engineering department, College of Engineering, or any other Carnegie Mellon department. However, students may only use one elective slot for a physical education course or for ROTC. We offer these electives so students can pursue individual interests or obtain a minor or double major.

Constructing a Program of Study

In order to properly plan their course sequence, students should select their six elective courses with the department academic advisor. If students are pursuing minors, double majors, or double degrees, they should choose electives that meet requirements of these programs. We provide more information on selecting courses and electives in the Undergraduate Student Handbook. We offer the following options to students for tailoring our program to fit their needs and interests.

Specialization Within Mechanical Engineering

Students can specialize in a specific area by taking additional mechanical engineering electives beyond the one required technical elective. Students can choose courses from the Mechanical Engineering Technical Electives list or take approved mechanical engineering graduate courses.

Research and Independent Study Projects

Students can work on a design or research project if supervised and coordinated by a faculty advisor. Interested students should contact faculty members to identify potential projects of mutual interest. Projects generally involve lab, analytical, field, design or computer work.

Students complete projects and research by taking either or both of the following courses for their electives. As previously mentioned, students cannot use these courses to fulfill the technical elective requirement.

24-391/392	Mechanical Engineering Project	Var.
24-491/492	Department Research Honors	Var.

*Students enrolled in 24-391/392 do not have an additional QPA (quality point average) requirement for this course.

Qualified students enrolled in 24-491/492 are recognized at commencement. To graduate with research honors, students must have a QPA of 3.2 or higher, complete 18 units of 24-491/492 with at least at least a "B" grade, and submit an approved thesis to their faculty research advisor.

Students who complete all requirements for CIT Honors Research will also graduate with research honors. These students must complete 18 units of (39-500) CIT Honors Research under the supervision of a mechanical engineering faculty member.

Developing a Concentration of Interdisciplinary Studies

Students can also take courses outside of mechanical engineering to fill elective slots. Usually students select courses around a common theme; although courses span several departments, students choose courses to form a specific concentration. Students can either construct an informal program of study based on their interests or they can pursue a minor or double major using these courses.

Pursuing a Minor or Double Major

The College of Engineering offers designated minors for students wishing to specialize in an engineering area. Students can find a list of minors on the CIT website (www.cit.cmu.edu). Students can generally complete a designated minor without increasing the number of units required for

graduation, but they should plan early so that they can complete a minor on time.

Students can also complete a double major within the College of Engineering. Students can earn double majors in Mechanical Engineering and Engineering and Public Policy, Mechanical Engineering and Biomedical Engineering or Mechanical Engineering and Robotics.

Additionally, students can pursue minors or double majors with other Carnegie Mellon departments. Interested students should contact the main department of the minor/double major they seek to learn the requirements for that program.

Advising

The department academic advisors are assigned initially to all new students and will continue to assist with any curriculum questions and registration issues until they graduate. Students choose their Faculty Mentor at the end of their sophomore year. Students should attend the fall sophomore lunch to meet professors, utilize introductions during sophomore core classes and check the website for additional faculty information.

The department academic advisors will:

- Verify progress toward degree requirements
- Discuss course alternatives for CIT requirements and electives
- Register research credit
- Assist with pre-requisite waivers
- Offer basic information regarding double major/minors, study abroad procedures, etc
- Explain summer transfer credit policies

Faculty mentors will:

- Explain technical content of coursework
- Suggest appropriate concentrations that match students' career objectives
- Discuss research opportunities
- Offer graduate school and employment advice
- Offer general advice and mentoring

As a regular part of monitoring progress toward completion of the degree, students should compare their transcripts with the department's degree requirements on the Academic Audit linked on the HUB website-www.cmu.edu/hub.

Integrated Master's/Bachelor's Degree (IMB)

The Integrated Master's/Bachelor's program (IMB) is an exciting opportunity for students who excel academically and want to pursue both a Bachelor's degree and a Master's Coursework (MSC) degree in Mechanical Engineering. The application fee, Graduate Record Exam (GRE), and recommendation letters are waived. The Bachelor's degree may be completed simultaneously with the MS degree or in a preceding semester. Courses taken for the MSC degree may not be counted in the Bachelor degree requirements. The two degrees are typically completed in 8 to 10 semesters. At least one semester of full time graduate status is required when completion of the two degrees extends beyond the 8th semester.

A student with a cumulative QPA of 3.00 or higher in the second semester of their junior or senior year is guaranteed admission into the MS degree through the IMB program. To be officially admitted, the student must complete the IMB degree program form: MechE IMB Form (https://docs.google.com/forms/d/1bQGUY6VtDtRJoLMC-nlFFRF1kPCTMeXcRmZJYWM2BNM/viewform).

If a student does not meet the exact overall 3.00 QPA requirement, they must apply for admission via the Graduate Admissions guidelines (http://www.cmu.edu/me/prospective/graduate-admission.html). All portions of the application must be completed.

Quality Point Average Requirements

To be eligible to graduate, undergraduate students must complete all course requirements for their program with a cumulative Quality Point Average of at least 2.00 for all courses taken. For undergraduate students who enrolled at Carnegie Mellon as freshmen and whose freshman grades cause the cumulative QPA to fall below 2.0, this requirement is modified to be a cumulative QPA of at least 2.0 for all courses taken after the freshman year. Note, however, the cumulative QPA that appears on the student's final transcript will be calculated based on all grades in all courses taken, including freshman year. The Mechanical Engineering Department requires that students attain a quality point average of 2.00 or higher for all required Mechanical Engineering core courses.

Pursuant to university rules, students can repeat a course in which a grade below C was attained in order to achieve the QPA requirement. When a course is repeated, all grades will be recorded on the official academic transcript and will be calculated in the student's QPA. For all required Mechanical Engineering courses, the highest grade obtained between the original and the repeated class will be used to calculate the Mechanical Engineering OPA.

Full-Time Faculty

SHELLEY ANNA, Professor of Mechanical Engineering – Ph.D, Harvard University; Carnegie Mellon, 2003–.
MARK BEDILLION, Associate Professor of Mechanical Engineering – Ph.D, Carnegie Mellon University; Carnegie Mellon, 2016–.
JACK LEE BEUTH, Professor of Mechanical Engineering – Ph.D., Harvard University; Carnegie Mellon, 1992–.
JONATHAN CAGAN, George Tallman and Florence Barrett Ladd Professor of Mechanical Engineering – Ph.D, University of California, Berkeley; Carnegie Mellon, 1990–.
STEVEN COLLINS, Associate Professor of Mechanical Engineering – Ph.D, University of Michigan; Carnegie Mellon, 2010–.
MAARTEN P. DE BOER, Professor of Mechanical Engineering – Ph.D, University of Minnesota; Carnegie Mellon, 2007–.
B. REEJA JAYAN, Assistant Professor of Mechanical Engineering – Ph.D, University of Texas-Austin; Carnegie Mellon, 2015–.
AARON M. JOHNSON, Assistant Professor of Mechanical Engineering – Ph.D., University of Pennsylvania; Carnegie Mellon, 2016–.
LEVENT BURAK KARA, Associate Professor of Mechanical Engineering – Ph.D., Carnegie Mellon University; Carnegie Mellon, 2007–.
PHILIP R. LEDUC, William J. Brown Professor of Mechanical Engineering – Ph.D., The Johns Hopkins University; Carnegie Mellon, 2002–.
SHAWN LITSTER, Associate Professor of Mechanical Engineering – Ph.D, Stanford University; Carnegie Mellon, 2008–.
CARMEL MAJIDI, Assistant Professor of Mechanical Engineering – Ph.D., University of California, Berkeley; Carnegie Mellon, 2011–.
JONATHAN A. MALEN, Associate Professor of Mechanical Engineering – Ph.D, University of California, Berkeley; Carnegie Mellon, 2009–.
ALAN J.H. MCGAUGHEY, Professor of Mechanical Engineering – Ph.D., University of Michigan; Carnegie Mellon, 2005–.
JEREMY J. MICHALEK, Professor of Mechanical Engineering – Ph.D., University of Michigan; Carnegie Mellon, 2005–.
O. BURAK OZDOGANLAR, Ver Planck Professor of Mechanical Engineering – Ph.D, University of Michigan; Carnegie Mellon, 2004–.
ALBERT PRESTO, Assistant Research Professor of Mechanical Engineering – Ph.D, Carnegie Mellon University; Carnegie Mellon, 2012-–.
YOED RABIN, Professor of Mechanical Engineering – D.Sc., Technion-Israel Institute of Technology; Carnegie Mellon, 2000–.
ALLEN L. ROBINSON, Raymond J. Lane Distinguished Professor & Department Head – Ph.D., University of California, Berkeley; Carnegie Mellon, 1998–.
EDWARD STEPHEN RUBIN, Professor of Mechanical Engineering – Ph.D., Stanford University; Carnegie Mellon, 1969–.
SHENG SHEN, Assistant Professor of Mechanical Engineering – Ph.D., Massachusetts Institute of Technology; Carnegie Mellon, 2011–.
KENJI SHIMADA, Theodore Ahrens Professor of Engineering – Ph.D., Massachusetts Institute of Technology; Carnegie Mellon, 1996–.
SATBIR SINGH, Assistant Teaching Professor of Mechanical Engineering – Ph.D, University of Wisconsin-Madison; Carnegie Mellon, 2012–.
METIN SITTI, Professor of Mechanical Engineering – Ph.D., University of Tokyo; Carnegie Mellon, 2002–.
KOUSHIL SREENATH, Assistant Professor of Mechanical Engineering – Ph.D., University of Michigan at Ann Arbor; Carnegie Mellon, 2013–.
PAUL SETH STEIF, Professor of Mechanical Engineering – Ph.D., Harvard University; Carnegie Mellon, 1983–.
RYAN SULLIVAN, Assistant Professor of Mechanical Engineering – Ph.D., University of California at San Diego; Carnegie Mellon, 2012–.
REBECCA TAYLOR, Assistant Professor of Mechanical Engineering – Ph.D., Stanford University; Carnegie Mellon, 2016–.
VENKAT VISWANATHAN, Assistant Professor of Mechanical Engineering – Ph.D., Stanford University; Carnegie Mellon, 2013–.
KATE S. WHITEFOOT, Assistant Professor of Mechanical Engineering – Ph.D., University of Michigan; Carnegie Mellon, 2016–.
SHI-CHUNE YAO, Professor of Mechanical Engineering – Ph.D., University of California, Berkeley; Carnegie Mellon, 1977–.
YONGJIE ZHANG, Associate Professor of Mechanical Engineering – Ph.D., University of Texas at Austin; Carnegie Mellon, 2007–.

Emeriti

ADNAN AKAY, Lord Emeritus Professor of Mechanical Engineering – PhD, North Carolina State University; Carnegie Mellon, 1992–.
NORMAN CHIGIER, Emeritus Professor of Mechanical Engineering – Sc.D., University of Cambridge; Carnegie Mellon, 1981–.
JERRY HOWARD GRIFFIN, William J. Brown Emeritus Professor of Mechanical Engineering – Ph.D., California Institute of Technology; Carnegie Mellon, 1981–.
WILFRED THOMAS ROULEAU, Emeritus Professor of Mechanical Engineering – Ph.D., Carnegie Institute of Technology; Carnegie Mellon, 1954–.