Department of Mechanical Engineering

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The profession of mechanical engineering, second largest among engineering disciplines, involves the design, analysis, and manufacturing of new products and technologies. Central to the profession is the importance of innovation in applying mechanical engineering fundamentals to address society's needs. The Department's curriculum is structured to provide students with the analytical tools, technical skills, engineering insights, and practical problem solving abilities that are necessary to convert a concept into a reliable, cost–effective, and safe device.

Mechanical engineers are employed by small start–ups, multinational corporations, government agencies, national laboratories, consulting firms, and universities. They can work in the areas of research, design, manufacturing, sales, quality assurance, or management. Mechanical engineers work in teams that design jet engines; automobiles; aircraft and spacecraft; microelectromechanical acceleration and pressure sensors; heating, ventilation, and air conditioning systems; power generation systems; biomedical and biomechanical devices such as artificial hip implants; and such integrated mechanical and electronic (mechatronic) systems as robots. The Department of Mechanical Engineering at Carnegie Mellon University is respected for the many significant advances in these technologies and others that have been made by its alumni and faculty.

The Department's curriculum provides students with a solid foundation upon which they can build to meet the challenges associated with their individual career paths, and to adapt to the rapidly changing technologies faced by today's engineers. Early in their education, Carnegie Mellon students develop a strong scientific foundation by taking courses in mathematics, physics, computer programming, and chemistry. In addition, all students are exposed at the Freshman level to two engineering disciplines through introductory courses taught by each department in the engineering college. The Department's Freshman–level course is project–oriented, and it introduces students to the various disciplines of mechanical engineering through lecture, laboratories, and hands–on learning. In the Sophomore and Junior years, students take core engineering courses in solid and fluid mechanics, thermodynamics, heat transfer, dynamics, systems and controls, design methods and skills and numerical methods.

While the program's emphasis on fundamentals is demanding, the Department's curriculum is also flexible and enables students to (i) begin taking elective courses during the Junior year, (ii) develop a specialization within mechanical engineering, (iii) develop a technical emphasis within another engineering or science department, or (iv) pursue studies in any other Carnegie Mellon department, such as foreign languages, economics, or design. This approach to engineering education recognizes the broader role that mechanical engineers play in society, as leaders in business, government, and law. During the Senior year, students take electives and capstone courses in engineering analysis and design with projects that often result in prototype hardware for new products. Students work in teams, on projects of their choosing, and are exposed to the design process from conceptualization to production. Recent examples include low–squeal disk brakes, high efficiency engines, neck gear to minimize spinal cord injury in sports, a stabilizer support arm for movie cameras, and equipment to improve the mobility of disabled persons. Effective writing, speaking and presentation skills, and engineering ethics are also emphasized as important attributes of successful leaders.

Throughout the undergraduate program, beginning in the first year, students use the latest computer–based design and analysis methods in their courses and project work. An undergraduate computing laboratory is available for design work, structural and thermal/fluid finite element analyses, and dynamic system simulations. Students work with industry–standard computer aided design tools to develop engineering drawings, and to visualize the performance of those parts through computer simulation before they are fabricated. After the design is optimized, the computer model can be down–loaded to a multi–axis computer–controlled milling machine, from which the part is manufactured. Other resources within the Undergraduate Design and Manufacturing Laboratory include MIG welding, rapid prototyping, and a full student shop equipped with lathes, drill presses, milling machines, band saws, and other hand and power tools. In coursework and projects, students work with state–of–the–art instrumentation and laboratory equipment, including spectrum analyzers, digital oscilloscopes, multi–waveform generators, and sensors which measure acceleration, strain, pressure, temperature, and force. Through such experiences, the Department emphasizes the modern industrial practice of seamlessly integrating computer–based design, analysis, characterization, and manufacturing.

Through electives and special degree programs, mechanical engineering students are able to pursue their personal interests both inside and outside the Department. Advanced courses in mechanical engineering are available in such areas as energy conversion, control, vibration, dynamics, manufacturing, robotics, internal combustion engines, mechatronics, fluid and solid mechanics, aerodynamics, and engineering design. Mechanical engineering students can also take a wide variety of technical and non–technical electives from other departments in order to develop a double major, minor, or concentration through an individualized program of study that is developed in collaboration with a faculty advisor. Many students choose to include a study abroad experience as part of their undergraduate education. The Department actively assists students in picking universities and courses abroad that will enhance their degree program. During their studies, many students also participate in faculty research projects, as laboratory assistants or through structured project work for academic credit. Students often find that exposure to solving open–ended research problems provides the ultimate educational experience.

The Department also offers an Accelerated Graduate Program, with access restricted to Carnegie Mellon undergraduates. In this program, students can take graduate courses during the Senior year in order to receive academic credit towards the Master's degree. After being admitted to the program, students can complete the coursework–based M.S. degree with only an additional summer and one semester of study beyond the traditional B.S. program.

In addition to teaching, the Department's faculty are actively involved in research sponsored by industry, consortia, and government agencies. Results of the research often serve as specific examples, case studies, and projects in undergraduate courses. Frequent seminars are sponsored by the Department, and they keep both students and faculty aware of recent advances in mechanical engineering and its related fields. Speakers of national and international reputation are invited to give these lectures. Seminars are open to all students within the Department, and they can provide students with a broad perspective on the mechanical engineering profession.

Additional information about the program is available through the Department's web page located at www.me.cmu.edu. The Department's Undergraduate Student Handbook includes further description of the Department's resources and policies. The handbook is distributed to sophomores in the Department each Fall, and is also available on–line at the Department's main web site. Additional copies can be requested in SH 416.

Educational Objectives

The highest–level objective of Carnegie Mellon University's mechanical engineering undergraduate program is to make positive, substantive, and lasting contributions to the lives of our students. This overall objective is articulated by the following two program educational objectives:

1. Graduates will recognize that they have obtained a high quality and rigorous technical education that is enriched by a flexible curriculum and interdisciplinary research opportunities.
2. Graduates will have applied their education to pursue successful career paths in either the engineering profession or an alternative field

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 multi–disciplinary teams

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

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 life–long learning

J. a knowledge of contemporary issues

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

Overview of the Curriculum

The Department's program fully meets the requirements of an accredited curriculum in mechanical engineering as certified by the Accreditation Board for Engineering and Technology (ABET).

Curriculum

The following template for the four–year B.S. program depicts the standard and recommended course sequences. In order to ensure that prerequisites are satisfied, and to prevent scheduling conflicts, students should discuss any significant deviation from this exemplar with the department academic advisor.

Freshman Year

	Fall	Units
21–120	Differential and Integral Calculus	10
24–101	Fundamentals of Mechanical Engineering	12
33–106	Physics for Engineering Students I	12
99–101	Computing @ Carnegie Mellon	3
76–101	Interpretation and Argument	9
		44
	Spring	
21–122	Integration, Differential Equations, and Approximations	10
xx–xxx	Second Introductory Engineering Course	12
xx–xxx	Restricted Technical Elective	10–13
xx–xxx	General Education Course	9
		41–44

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
xx–xxx	General Education Course	9
		48–51
	Spring	
21–260	Differential Equations	9
24–231	Fluid Mechanics	10
24–262	Stress Analysis	12
xx–xxx	Restricted Technical Elective	10–13
xx–xxx	General Education Course	9
		50–53

Junior Year

	Fall	Units
24–302	Mechanical Engineering Seminar (or spring)	2
24–311	Numerical Methods	12
24–322	Heat Transfer	10
24–351	Dynamics	10
36–220	Engineering Statistics and Quality Control	9
xx–xxx	General Education Course	9
		52
	Spring	
24–370	Engineering Design I: Methods and Skills	12
24–321	Thermal Fluids Experimentation and Design	12
24–352	Dynamic Systems and Control	12
xx–xxx	General Education Course	9
		45

Senior Year

	Fall	Units
24–441	Design II: Conceptualization and Realization *or*	12
xx–xxx	Elective	9
24–452	Mechanical Systems Experimentation	9
xx–xxx	Elective	9
xx–xxx	Elective	9
xx–xxx	General Education Course	9
		48
	Spring	
24–441	Design II: Conceptualization and Realization *or*	12
xx–xxx	Elective	9
24–xxx	Mechanical Engineering Technical Elective	9–12
xx–xxx	Elective	9
xx–xxx	Elective	9
xx–xxx	General Education Course	9
		45–51

Notes on the Curriculum

1. A minimum of 380 units is required for completion of the B.S. degree.
2. In the Freshman year, 24-101 Fundamentals of Mechanical Engineering can be taken in either the Fall or Spring semesters.

   A second introductory engineering course is taken in the other semester of the Freshman year.

   For those students who did not complete 24-101 Fundamentals of Mechanical Engineering during the Freshman year, this course should be taken during the Fall semester of the Sophomore year in place of the General Education Course. In this event, the replaced General Education Course should be taken during the Junior or Senior years. The additional introductory engineering course can be used to fulfill one of the Elective requirements as described below.
3. By the end of the Sophomore year, a mechanical engineering student should have completed the following mathematics, computer science, and introductory engineering courses:

21-120	Differential and Integral Calculus	10
21-122	Integration, Differential Equations and Approximation	10
21-259	Calculus in Three Dimensions	9
21-260	Differential Equations	9
33-106*	Physics I for Engineering Students	12
33-107*	Physics II for Engineering Students	12
XX-XXX	Science Laboratory Requirement	3-12
09-105	Modern Chemistry 1	10
15-100	Introductory/Intermediate Programming	10
or		
15-111	Intermediate/Advanced Programming	10
24-101	Introduction to Mechanical Engineering	12
xx-xxx	Second Introductory Engineering Course	12

* 33-106/107 is the recommended sequence for engineering students, although 33-111/112 or 33-131/132 would also meet the CIT Physics requirement.

Mechanical engineering undergraduates must satisfy a Science Laboratory requirement to graduate. Normally the Science Laboratory requirement is satisfied by passing 09-101 Introduction Experimental Chemistry (3 units). Students can also satisfy the Science Laboratory requirement by passing one of the following courses:

a. 03-124 Modern Biology Laboratory (9 units)
b. 33-100 Basic Experimental Physics (6 units)
c. 33-104 Experimental Physics (9 units)
d. 33-453 Intermediate Optics (12 units)
e. 42-203 Biomedical Engineering Laboratory (9 units)

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

4. Students are required to complete 36-220, Engineering Statistics and Quality Control, which may be scheduled in any semester. The sequence of calculus courses (21-120, 21-122, 21-259) and Differential Equations (21-260) 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:

   24-302 ME Seminar (2 units either fall or spring)
   70-340 Business Communications (9 units)
6. In the Senior year, students enroll in Mechanical Systems Experimentation (24-452) in the fall. Engineering Design II (24-441) may be taken in either fall or spring.

Restricted Technical Electives

By the end of the Sophomore year, students should have completed each of the following courses, which are listed as "Restricted Technical Electives" in the exemplary curriculum. Students have some flexibility in the sequencing of these courses during the Freshman and Sophomore years:

		Units
33–107	Physics for Engineering Students II	12
09–101	Introduction to Experimental Chemistry	3
09–105	Modern Chemistry I	10
15–100	Introductory/Intermediate Programming	10
or		
15–111	Intermediate/Advanced Programming	10

Mechanical Engineering Technical Electives

Students are required to take at least one elective offered by the Department. These elective courses are listed as "Mechanical Engineering Technical Electives" in the exemplary curriculum. The courses below are grouped according to their discipline within mechanical engineering, and students can select courses from the same discipline or from different ones. Students must take at least one of the following courses for a minimum of 9 units to fulfill the Mechanical Engineering Technical Elective requirement:

Design and Manufacturing

24–201	Engineering Graphics
24–341	Manufacturing Sciences
24–443	Design for Manufacture

Mechanical Systems

24–353	Intermediate Dynamics
24–355	Kinematics and Dynamics of Mechanisms
24–356	Engineering Vibrations
24–361	Intermediate Stress Analysis
24–451	Feedback Control Systems

Thermal–Fluid Systems

24–331	Viscous Flow
24–332	Potential Flow and Aerodynamics
24–333	Gas Dynamics
24–415	Microfluidics
24–421	Internal Combustion Engines
24–423	Direct Energy Conversion
24–424	Energy and the Environment
24–425	Combustion and Air Pollution Control

Special Topics

24–380–386	Special Topics in Mechanical Engineering

These courses are offered regularly according to the Department's teaching schedule. However, the offering of a particular course in a given semester can not be guaranteed.

24–391/392 Mechanical Engineering Project, 24–491/492 Departmental Research Honors, and 39–xxx series courses can not be used to satisfy the Mechanical Engineering Technical Elective requirement. However, those courses can be taken in the remaining five Elective slots.

Undergraduate students can also take certain graduate courses which are offered by the Department in order to satisfy the Mechanical Engineering Technical Elective requirement, provided that the appropriate prerequisites have been met and the student has secured the approval of the course's instructor. Graduate courses offered by the Department are listed on the Department Website.

Electives

Students are required to complete five courses which are listed as "Electives" in the exemplary curriculum. These electives can be technical or non–technical courses. Only one such elective can be taken in the areas of Physical Education (69–xxx) or ROTC (30–xxx, 31–xxx, and 32–xxx).

Elective courses can be taken in the Mechanical Engineering Department, in other departments within the College of Engineering, or in any other department of the University. This feature of the curriculum is intended to provide students with sufficient flexibility to allow specialization in a wide variety of fields, and to facilitate minor and double major curricula.

Constructing a Program of Study

A total of six electives (one Mechanical Engineering Technical Electives and five Electives) are available to students. These courses should be selected through consultation with the academic advisor, and reflect long–term planning on the part of the student. For instance, the electives can be allocated in order to meet the requirements of minor, double major, or double degree programs. The Department's Undergraduate Student Handbook provides additional information on course and elective selection. Options available to students for structuring their programs of study include the following:

Specialization Within Mechanical Engineering

Students can develop deeper focus within mechanical engineering by using the Elective slots to take additional courses offered by the Department beyond the one required Mechanical Engineering Technical Elective. These courses can be chosen from the list of Mechanical Engineering Technical Electives, or from the list of the Department's graduate courses.

Research and Independent Study Projects

Students can pursue independent study within the Department on a design or research project under the supervision and coordination of a faculty advisor. Interested students are encouraged to contact faculty members and identify potential project areas of mutual interest. Mechanical engineering projects generally involve open–ended problem solving with laboratory, analytical, field, design, or computa–tional work.

Students complete projects and research by taking either or both of the following courses within the Elective slots:

24–391/392	Mechanical Engineering Project
24–491/492	Departmental Research Honors

These courses do not qualify as Mechanical Engineering Technical Electives. There is no additional quality point average (QPA) requirement for students who choose to enroll in 24–391/392 Mechanical Engineering Project. Qualified students can pursue 24–491/492 Departmental Research Honors and receive such recognition at commencement. In order to graduate with research honors, a student must have attained a QPA of 3.2 or higher at graduation, have completed 18 units of 24–491/492 Departmental Research Honors in which grades of B or better were attained, and have submitted an approved thesis to the faculty advisor.

A student who completes all requirements for CIT Honors Research will also graduate with Departmental Research Honors upon completion of 18 units of 39–500 CIT Honors Research. Such research projects must be conducted under the supervision of a mechanical engineering faculty member.

Student–Structured Interdisciplinary Studies

Using the Elective slots, students can take courses outside the Mechanical Engineering Department in technical or non–technical areas. For instance, depending on a student's particular career interests, courses can be taken in such departments as Design, Biomedical Engineering, or Materials Science and Engineering, or through the College of Engineering's interdisciplinary 39–xxx series. Often, Elective courses are selected around a common theme that can span several departments, and are chosen so as to form a student–structured area of concentration. Such programs of study can be constructed in an informal manner by the student and his or her advisor, or they can be part of a minor or double major program.

Minors and Double Majors

The College of Engineering offers a series of designated minors in different areas of engineering specialization. The Elective, and Mechanical Engineering Technical Elective slots can be used to complete the requirements of these minors. Although students can generally complete a designated minor without increasing the number of units required for graduation, early planning is important.

Double major programs within the College of Engineering are also available. Students in the Department can earn double majors in (i) Mechanical Engineering, and Engineering and Public Policy, and (ii) Mechanical Engineering, and Biomedical and Health Engineering.

In addition, many departments in the University offer minor and double major degree programs. The Elective slots available to mechanical engineering students can be used to advantage in completing the requirements for a minor or double major, but early schedule planning is important. Interested students should contact the main office in the department of interest and inquire as to those requirements.

Advising

The department academic advisor is assigned initially to all new students and will continue to assist with any curriculum questions and registration issues for the remainder of their studies.

During the sophomore year, students are encouraged to request a faculty mentor. To assist in this process, students should attend the fall sophomore dinner to meet professors, utilize faculty introductions provided during sophomore core classes and check the website for additional faculty information (Current Students–Advising). Faculty appointments as needed may also be arranged through the academic advising office. The academic advisor will assign a faculty mentor to students that have not indicated a selection at the end of the sophomore year.

Faculty will:

· Explain technical content of coursework and suggest concentrations appropriate to career objectives
· Discuss research and summer internship opportunities
· Offer graduate school and employment path advice
· Offer general advice and mentoring

The Academic Advisor 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

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

Accelerated Graduate Program

An accelerated program is available to Carnegie Mellon undergraduate students who also wish to complete a coursework Master's degree in mechanical engineering. Exceptional students can apply for admission to the program at the end of the first semester of the Senior year and must meet the requirements for admission to the Department's graduate program. Financial aid in the form of Teaching or Research Assistantships is not offered to students in the Accelerated Graduate Program.

In this program, students must complete at least 24 units of graduate coursework by the end of the Senior year. A grade of 3.0 or better must be attained in those courses, and they can not be used to satisfy the requirements of the baccalaureate degree. During the summer immediately after the Senior year, students complete up to 24 units of 24–793 Supervised Reading and 24–794 Master of Science Project. During the following Fall semester, students then complete all remaining coursework. A total of 96 units is required for completion of the coursework Master's degree. Students who wish to pursue the Accelerated Graduate Program should contact the graduate coordinator in the Department's main office for further information.

Quality Point Average Requirements

In addition to the College of Engineering's requirement of a cumulative quality point average (QPA) of 2.00 or higher for all courses taken after the Freshman year, the Mechanical Engineering Department requires that students attain a quality point average of 2.00 or higher for all required Mechanical Engineering 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. The highest grade so obtained will be used to calculate the quality point average for all required Mechanical Engineering courses.

Faculty

ADNAN AKAY, Lord Professor of Mechanical Engineering — Ph.D., North Carolina State University; Carnegie Mellon, 1992—.

CRISTINA HORTENSIA AMON, Lane Distinguished Professor of Mechanical Engineering — Sc.D., Massachusetts Institute of Technology; Carnegie Mellon, 1988—.

SHELLEY ANNA, Associate Professor of Mechanical Engineering — Ph.D., Harvard University; Carnegie Mellon, 2003 —.

NADINE N. AUBRY, Professor of Mechanical Engineering; Head, Department of Mechanical Engineering – Ph.D., Cornell University; Carnegie Mellon, 2006.

JACK LEE BEUTH,Professor of Mechanical Engineering — Ph.D., Harvard University; Carnegie Mellon, 1992—.

JONATHAN CAGAN, Professor of Mechanical Engineering — Ph.D., University of California, Berkeley; Carnegie Mellon, 1990—.

NORMAN CHIGIER, Professor of Mechanical Engineering, Emeritis — Sc.D., University of Cambridge; Carnegie Mellon, 1981—.

JERRY HOWARD GRIFFIN, William J. Brown Professor of Mechanical Engineering — Ph.D., California Institute of Technology; Carnegie Mellon, 1980— .

C. FRED HIGGS III, Associate Professor of Mechanical Engineering — Ph.D., Rensselaer Polytechnic Institute; Carnegie Mellon University, 2003—.

LEVENT BURAK KARA, Assistant Professor of Mechanical Engineering — Ph.D., Carnegie Mellon University; Carnegie Mellon, 2007—.

PHILIP R. LeDUC, Associate Professor of Mechanical Engineering — Ph.D., The Johns Hopkins University; Carnegie Mellon, 2002—.

SHAWN LITSTER, Assistant Professor of Mechanical Engineering — Ph.D., Stanford University; Carnegie Mellon, 2008—.

ALAN J.H. McGAUGHEY, Assistant Professor of Mechanical Engineering—Ph.D., University of Michigan; Carnegie Mellon, 2005–.

WILLIAM CHARLES MESSNER, Professor of Mechanical Engineering — Ph.D., University of California, Berkeley; Carnegie Mellon, 1993—.

JEREMY J. MICHALEK, Assistant Professor of Mechanical Engineering –Ph.D., University of Michigan; Carnegie Mellon, 2005–.

JOHN FLETCHER OSTERLE, Theodore Ahrens Professor of Mechanical Engineering, Emeritus — D.Sc., Carnegie Mellon University; Carnegie Mellon, 1946—.

O. BURAK OZDOGANLAR, Associate Professor of Mechanical Engineering — Ph.D., University of Michigan; Carnegie Mellon, 2004—.

YOED RABIN, Professor of Mechanical Engineering — D.Sc., Technion–Israel Institute of Technology; Carnegie Mellon University, 2000—.

ALLEN L. ROBINSON, Professor of Mechanical Engineering, and Engineering and Public Policy — Ph.D., University of California, Berkeley; Carnegie Mellon, 1998—.

WILFRED THOMAS ROULEAU, Professor of Mechanical Engineering, Emeritus — Ph.D., Carnegie Mellon University; Carnegie Mellon, 1954—.

EDWARD STEPHEN RUBIN, Professor of Mechanical Engineering and Engineering and Public Policy — Ph.D., Stanford University; Carnegie Mellon, 1969—.

KENJI SHIMADA, Professor of Mechanical Engineering — Ph.D., Massachusetts Institute of Technology; Carnegie Mellon, 1996—.

METIN SITTI, Associate Professor of Mechanical Engineering — Ph.D., University of Tokyo; Carnegie Mellon, 2002—.

PAUL SETH STEIF, Professor of Mechanical Engineering — Ph.D., Harvard University; Carnegie Mellon, 1983—.

JOHN WILLIAM WISS, Adjunct Professor of Mechanical Engineering — M.Mech.E., Rensselaer Polytechnic Institute; Carnegie Mellon, 1982—.

SHI–CHUNE YAO, Professor of Mechanical Engineering — Ph.D., University of California, Berkeley; Carnegie Mellon, 1977—.

YONGJIE ZHANG, Assistant Professor of Mechanical Engineering — Ph.D., University of Texas at Austin; Carnegie Mellon, 2007—.