Mechanical Engineering, B.S.

Program 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.”

The core objective of our undergraduate program is to provide our students an education that enables them to be productive, impactful, and fulfilled professionals throughout their careers. In light of this vision, the program educational objectives of the Bachelor of Science in Mechanical Engineering at Carnegie Mellon are to produce graduates who:

- Distinguish themselves as effective problem solvers who are capable of applying fundamentals of mechanical engineering alongside modern experimental and computational methods.
- Are innovative and resourceful in their professional activities.
- Excel in team settings, incorporating diverse viewpoints and ideas and implementing strategies for equitable participation.
- Become effective communicators who are prepared to take on leadership roles in their organizations, their profession, and in society.
- Conduct themselves in a professional and ethical manner in the workplace.
- Excel in diverse career paths within and beyond engineering profession, including in industry, academia, and government.

Student Outcomes

The undergraduate curriculum in the Department of Mechanical Engineering offers students significant opportunities to pursue directions of personal interest, including minors, additional 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.

Carnegie Mellon's Mechanical Engineering faculty members are in support of the following set of skills and outcomes put forth by ABET:

- an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics
- an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors
- an ability to communicate effectively with a range of audiences
- an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts
- an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives
- an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions
- an ability to acquire and apply new knowledge as needed, using appropriate learning strategies

Curriculum

Minimum units required for B.S. in Mechanical Engineering: 382

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. Students need a minimum of 382 units to complete the B.S. degree. Since there are variable units for some core requirements, additional units can be made up with free electives.

First 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	Core@CMU	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	Physics II/Computer Science/Chemistry*	10-12
xx-xxx	General Education Course	9
		41-43

First Year Curriculum Notes:

1. During the first year, Mechanical Engineering students complete 24-101 Fundamentals of Mechanical Engineering and one other introductory engineering course. 24-101 Fundamentals of Mechanical Engineering is a prerequisite for sophomore courses 24-261 Mechanics I: 2D Design , 24-221 Thermodynamics and 24-251 Electronics for Sensing and Actuation, as well as junior course 24-351 Dynamics. Students who are not able to take 24-101 in their first year will push the 24-261 Mechanics I: 2D Design, and 24-262 Mechanics II: 3D Design sequence into their junior year as well as 24-221 Thermodynamics. If 24-101 is taken in fall of sophomore year, students can take 24-251 Electronics for Sensing and Actuation 24-231 Fluid Mechanics and 24-351 Dynamics in sophomore spring to continue progress towards the Mechanical Engineering degree.
2. All Mathematics courses (21-xxx) required for the engineering degree must have a minimum grade of C in order to fulfill the graduation requirement for the BS engineering degree and to count as a prerequisite for engineering core classes.
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
   21-122 Integration and Approximation
   33-141 Physics I for Engineering Students

Sophomore Year

Fall		Units
24-221	Thermodynamics	10
24-261	Mechanics I: 2D Design	10
21-254	Linear Algebra and Vector Calculus for Engineers	11
xx-xxx	Physics II/Computer Science/Chemistry*	10-12
24-xxx	24-203 TechSpark:Manual Machining OR 24-251 Electronics for Sensing and Actuation **and***	3-4
xx-xxx	General Education Course	9
39-210	Experiential Learning I	0
		53-56

Spring		Units
24-231	Fluid Mechanics	10
24-262	Mechanics II: 3D Design	10
21-260	Differential Equations	9
xx-xxx	Physics II/Computer Science/Chemistry*	10-12
24-xxx	24-203 TechSpark: Manual Machining OR 24-251 Electronics for Sensing and Actuation **and***	3-4
xx-xxx	General Education Course	9
39-220	Experiential Learning II	0
		51-54

* **Physics II/Chemistry/Computer Science:**
First year students are encouraged to prioritize completing Physics II and Programming requirement over Chemistry in the first year.
- The recommended Physics sequence is 33-141 (http://coursecatalog.web.cmu.edu/search/?P=33-141) / 33-142 (http://coursecatalog.web.cmu.edu/search/?P=33-142) for engineering students, however, 33-151 (http://coursecatalog.web.cmu.edu/search/?P=33-151) / 33-152 (http://coursecatalog.web.cmu.edu/search/?P=33-152) will also meet the CIT Physics requirement.
- The programming requirement can be filled with 15-110 Principles of Computing or 15-112 Fundamentals of Programming and Computer Science.

- The Chemistry requirement can be filled with 09-105 Introduction to Modern Chemistry I or 09-111 Chemical Building Blocks.

** **24-203 and 24-251 Completed Sophomore Year:**
24-203 TechSpark: Machine Shop Principles and 24-251 Electronics for Sensing and Actuation should be completed within the sophomore year, fall or spring. Both are required courses.

*** **Waiving Electronics for Sensing and Actuation:**
Mechanical Engineering (MechE) students who took the 18-100 Introduction to Electrical and Computer Engineering in their first year, have the option of waiving 24-251 Electronics for Sensing and Actuation. These units must be replaced with 3 units of graded Mechanical Engineering credit which could be done by taking a 12 unit MechE Technical Elective instead of a 9 unit course. Eligible students will be invited to complete a form to confirm their intention to waive 24-251.

Junior Year

Fall		Units
24-302	Professional Development for Mechanical Engineers (Offered Fall and Spring)	2
24-322	Heat Transfer	10
24-351	Dynamics (Offered Fall and Spring)	10
24-370	Mechanical Design: Methods and Applications	12
36-220	Engineering Statistics and Quality Control	9
xx-xxx	General Education Course	9
39-310	Experiential Learning III	0
		52

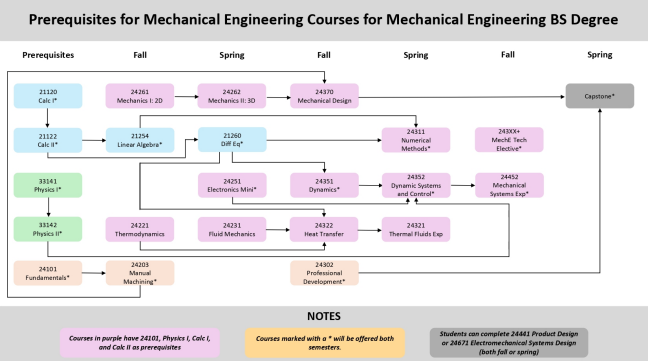
Spring		Units
24-302	Professional Development for Mechanical Engineers (Offered Fall and Spring)	2
24-311	Numerical Methods (Offered Fall and Spring)	10
24-321	Thermal-Fluids Experimentation	12
24-352	Dynamic Systems and Controls (Offered Fall and Spring)	12
xx-xxx	General Education Course	9
		45

Senior Year

Fall		Units
24-441	Product Design (Offered Fall and Spring) ****	12
or 24-671	Electromechanical Systems Design	
24-452	Mechanical Systems Experimentation (Offered Fall and Spring)	9
xx-xxx	Elective	9
xx-xxx	Elective	9
xx-xxx	General Education Course	9
		48

Spring		Units
24-xxx	Mechanical Engineering Technical Elective	9-12
xx-xxx	General Education Course	9
xx-xxx	Elective	9
xx-xxx	Elective	9
		36-39

*** **Capstone Courses:**
- Mechanical Engineering students complete **one** capstone class either fall or spring of senior year. This course is the culmination of the knowledge gained over the previous years in mechanical engineering core classes. To fulfill the capstone course requirement, students can complete one of the following 24-441 Product Design (FALL OR SPRING), 24-671 Electromechanical Systems Design (FALL OR SPRING).
- Capstone course can be taken either Fall or Spring of senior year.
- Biomedical Engineering Double Majors **may** use the capstone for their double major **instead of** the above listed MechE capstone classes.



Electives

Mechanical Engineering Technical Electives

Students must take at least one approved non-core Mechanical Engineering course labeled as “Mechanical Engineering Technical Elective” in the example course sequence. The course must be an approved 24-xxx course (9-unit minimum) at the 300 level or above to fulfill the technical elective requirement.

Students can also take mechanical engineering graduate courses to fulfill the technical elective requirement. Students must have the appropriate prerequisites for the course. The prerequisites for graduate level courses are usually listed under "prerequisite knowledge" in SIO. Undergraduates do not have priority for graduate level courses. Students are encouraged to follow the guidance in the Waitlist Navigation Guide (https://www.cmu.edu/hub/registrar/registration/waitlist-action-timeline.html) to improve chances of securing a seat.

Students can find a current list of courses on the Carnegie Mellon Schedule of Classes (https://enr-apps.as.cmu.edu/open/SOC/SOCServlet).

Students cannot use research or project courses to fulfill the technical elective requirement. However, these courses, with limitations, will count as free elective units. Up to 27 units of project/research may be counted in the free electives. Project/research courses that do not fulfill the technical elective requirements are:

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

Free Electives

A Free Elective is defined as any graded course offered by any academic unit of the university. Free electives offer students the opportunity to add additional majors and minors, pursue additional interests or deepen their experience in Mechanical Engineering. Typically, once the core requirements are completed, there remain about 45 units of free electives to reach the minimum of 382 to complete the degree.

Up to 9 units of Student Taught Courses (StuCO) and Physical Education courses, or other courses taken as Pass/Fail, may also be used toward Free Electives.

Guidance on Engineering Electives

The Mechanical Engineering department offers several elective courses for undergraduates seeking further knowledge and experience in specialty areas of mechanical engineering. These courses (with approval) can fulfill for your Mechanical Engineering Technical Elective, Free Electives, and/or additional major or minor requirements.

Robotics and Automation

Fundamental Courses		
24-451	Feedback Control Systems	12
24-677	Modern Control Theory	12
24-760	Robot Dynamics and Analysis	12
24-773	Multivariable Linear Control	12

24-776	Non Linear Control	12
Application Courses		
24-614	Microelectromechanical Systems	12
24-671	Electromechanical Systems Design	12
24-673	Soft Robots: Mechanics, Design and Modeling	12
24-753	Special Topics: Robotic Materials: Designs, Principles & Mechanics	12
24-774	Advanced Control Systems Integration	12
24-775	Bioinspired Robot Design and Experimentation	12
24-778	Mechatronic Design	12

Energy, Environment, and Thermal Fluid Systems

Fundamental Courses		
24-711	Fluid Dynamics	12
24-718	Computational Fluid Dynamics	12
24-721	Advanced Thermodynamics	12
24-722	Energy System Modeling	12
24-730	Advanced Heat Transfer	12
Application Courses		
24-381	Environmental Systems on a Changing Planet (Students must take 24-381 for Environmental Systems on a Changing Planet to fulfill the MechE Technical Elective requirement)	12
24-423	Renewable Energy Engineering	9
24-623	Molecular Simulation of Materials	12
24-626	Air Quality Engineering	12
24-628	Energy Transport and Conversion at the Nanoscale	12
24-629	Direct Solar and Thermal Energy Conversion	12
24-643	Energy Storage Materials and Systems	12

Product Design and Development

Fundamental Courses		
24-651	Material Selection for Mechanical Engineers	12
24-688	Introduction to CAD and CAE Tools	12
Application Courses		
24-632	Special Topics: Additive Manufacturing Processing and Product Development	12
24-633	Additive Manufacturing Laboratory	12
24-672	Special Topics in DIY Design and Fabrication	12
24-680	Quantitative Entrepreneurship: Analysis for New Technology Commercialization	12
24-691	Mechanical Engineering Project Management	12
24-692	Special Topics: Engineering a Startup: How to Start and Grow a Hardware Company	12

Autonomous Systems and Machine Learning

Fundamental Courses		
24-451	Feedback Control Systems	12
24-677	Modern Control Theory	12
24-704	Probability and Estimation Methods for Engineering Systems	12
24-789	Intermediate Deep Learning for Engineers	6
Application Courses		
24-774	Advanced Control Systems Integration	12
24-775	Bioinspired Robot Design and Experimentation	12
24-784	Special Topics: Trustworthy AI	12

Computational Engineering

Fundamental Courses		
24-703	Numerical Methods in Engineering	12
24-780	Engineering Computation	12
24-783	Advanced Engineering Computation	12
24-785	Engineering Optimization	12
Application Courses		
24-658	Image-Based Computational Modeling and Analysis	12
24-718	Computational Fluid Dynamics	12
24-755	Finite Elements in Mechanics I	12
24-781	Engineering Computation Project	Var.

Engineering Mechanisms and Materials

Fundamental Courses		
24-634	Structural Design	12
24-635	Structural Analysis	9
24-652	Mechanical Behavior of Engineering Materials	12
24-653	Special Topics: Materials and Their Processing for Mechanical Engineers	12
24-751	Solid Mechanics and Elasticity	12
Application Courses		
24-358	Culinary Mechanics	9
24-643	Energy Storage Materials and Systems	12
24-650	Applied Finite Element Analysis	12
24-684	Nanoscale Manufacturing Using Structural DNA Nanotechnology	12
24-755	Finite Elements in Mechanics I	12
24-753	Special Topics: Robotic Materials: Designs, Principles & Mechanics	12