Department of Mechanical Engineering

Allen Robinson, David and Susan Coulter Head of Mechanical Engineering
and Raymond J. Lane Distinguished Professor of Mechanical Engineering
Location: Scaife Hall 401
www.cmu.edu/eme

General Overview
Mechanical engineers use their knowledge of mechanical systems to describe phenomena, propose solutions to problems, and build those solutions. Concerned with the principles of force, energy and motion, they use their knowledge of physical systems, design, manufacture, and operational processes to advance the world around us. Mechanical engineers work in a variety of sectors: small start-up companies, multinational corporations, government agencies, national laboratories, consulting firms, and universities.

The Carnegie Mellon Mechanical Engineering curriculum emphasizes engineering theory, hands-on experience, and technical skills. Our students learn how to solve practical problems and analyze situations by converting ideas into reliable and cost-effective devices and processes.

A strong foundation in mechanical engineering fundamentals culminates in a design capstone class where student teams develop prototypes for new products. These projects expose students to the design process, from concept to product, and emphasize effective communication and presentations skills.

Our curriculum is intended to allow ample opportunity for students to pursue areas of personal interest. A student may choose to pursue a minor offered by departments in other colleges, or one of the designated minor programs offered in the College of Engineering, or to pursue an additional major. Students are encouraged to participate in research with department faculty members, explore their chosen field through internships, and take advantage of opportunities to study abroad and be exposed to other cultures. Students may also choose to pursue the Integrated Master’s Bachelor’s Program (IMB) which allows students to earn both a bachelor’s and a master’s degree with an additional semester or year of study.

Mechanical Engineering students access TechSpark for hands-on projects in multiple courses. TechSpark is the cornerstone of the College of Engineering’s maker ecosystem having an integrated set of resources where faculty and students create and develop new ideas, concepts, and products for technology innovation. The space houses a simulation cluster, 3D printers, laser machines, electronics stations, PCB fabrication, manual & CNC mills, metal welding, wood working & CNC Router, polymer composite fabrication, paint booth, and more to allow students, faculty, and staff to design and prototype in a multi-disciplinary environment.

Accreditation

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 objectives of the Bachelor of Science in Mechanical Engineering at Carnegie Mellon are to produce graduates who:

• distinguish themselves as effective problem solvers by applying fundamentals of Mechanical Engineering.
• are innovative and resourceful in their professional activities.
• excel in multidisciplinary team settings.
• become leaders 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 the engineering profession, including in industry and academia.

Educational Outcomes
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:

• an ability to apply knowledge of mathematics, science, and engineering
• an ability to design and conduct experiments, as well as to analyze and interpret data
• 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
• an ability to function on multidisciplinary teams
• an ability to identify, formulate, and solve engineering problems
• an understanding of professional and ethical responsibility
• an ability to communicate effectively
• the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context
• a recognition of the need for, and an ability to engage in life-long learning
• a knowledge of contemporary issues
• an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

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.

Freshman Year

<table>
<thead>
<tr>
<th>Fall</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>21-120</td>
<td>Differential and Integral Calculus</td>
</tr>
<tr>
<td>24-101</td>
<td>Fundamentals of Mechanical Engineering</td>
</tr>
<tr>
<td>33-141</td>
<td>Physics I for Engineering Students</td>
</tr>
<tr>
<td>99-101</td>
<td>Computing @ Carnegie Mellon</td>
</tr>
<tr>
<td>76-101</td>
<td>Interpretation and Argument</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Spring</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>21-122</td>
<td>Integration and Approximation</td>
</tr>
<tr>
<td>xx-xxx</td>
<td>Second Introductory Engineering Course</td>
</tr>
<tr>
<td>xx-xxx</td>
<td>Physics II/Chemistry/Computer Science*</td>
</tr>
<tr>
<td>xx-xxx</td>
<td>General Education Course</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
</tr>
</tbody>
</table>

Sophomore Year

<table>
<thead>
<tr>
<th>Fall</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>21-259</td>
<td>Calculus in Three Dimensions</td>
</tr>
<tr>
<td>xx-xxx</td>
<td>Physics II/Chemistry/Computer Science*</td>
</tr>
<tr>
<td>24-221</td>
<td>Thermodynamics I</td>
</tr>
<tr>
<td>24-261</td>
<td>Statics</td>
</tr>
<tr>
<td>xx-xxx</td>
<td>Machine Shop/Intro to CAD/ISC**</td>
</tr>
<tr>
<td>xx-xxx</td>
<td>Lab requirement ***</td>
</tr>
</tbody>
</table>
Junior Year

21-260 Differential Equations 9
24-231 Fluid Mechanics 10
24-262 Stress Analysis 12

To accommodate the new introduction to Scientific Computing course in the curriculum and maintain the 382 minimum units, starting Spring 2020, 24-262 Stress Analysis will be a 10 unit course.

9-12

xx-xxx General Education Course 9
39-210 Experiential Learning I 0

49-52

Spring

24-200 Introduction to CAD 24-202, and Introduction to Scientific Computing 24-281 should be completed by the end of sophomore year. If students take 24-282 Special Topics: Linear Algebra and Vector Calculus for Engineers or 21-254 (to be offered starting Spring 2020), the 24-281 requirement is waived because it will be incorporated into these classes.

General Education Course

Mechanical engineering undergraduates must satisfy a Science Laboratory requirement to graduate. The lab requirement may be fulfilled with one of the following courses:

9-12

09-101 Introduction to Experimental Chemistry 3
42-203 Biomedical Engineering Laboratory 9
03-124 Modern Biology Laboratory 9
33-100 Basic Experimental Physics 6
33-104 Experimental Physics 9

Junior Year

Fall

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

Students are encouraged to take 19-250 or 36-225 instead of 36-220 to meet the engineering statistics requirement. 36-217 will also count for the statistics requirement.

9-12

xx-xxx General Education Course 9
39-310 Experiential Learning III 0

52

Spring

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

24-441 Engineering Design II: Conceptualization and Realization - required either fall or spring; alternate with xx-xxx 9 unit elective
or 24-671 Special Topics: Electromechanical Systems Design

*BME and Robotics Double Majors may use the capstone for their double major instead of the above listed MechE capstone design classes*

24-452 Mechanical Systems Experimentation 9
xx-xxx Elective 9
xx-xxx Elective 9
xx-xxx General Education Course 9

48

Spring

24-441 Engineering Design II: Conceptualization and Realization - required either fall or spring; alternate with xx-xxx 9 unit elective. Or 24-631 Thermal Design, offered Spring ONLY.

24-671 Special Topics: Electromechanical Systems Design

*BME and Robotics Double Majors may use the capstone for their double major instead of the above listed MechE capstone design classes*

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 complete 24-101 Fundamentals of Mechanical Engineering and another introductory engineering course. Students who do not take 24-101 during their first year should take 24-101 Fundamentals of Mechanical Engineering during the 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 year.

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

4. 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. Students who substitute 24-282 Special Topics: Linear Algebra and Vector Calculus for Engineers for 21-259 are also required to have a minimum grade of C to fulfill this math requirement.

5. Students are required to complete an engineering statistics course. The department strongly encourages students to take 19-250 or 36-225 instead of 36-220, which may be scheduled in any semester. Students may also take 36-217 to fulfill this requirement.

6. The presentation skills requirement can be satisfied by completing one of the following options: 24-302 Mechanical Engineering Seminar I, 76-270 Writing for the Professions, 70-340 Business Communications

7. To fulfill the capstone design requirement, students must take either 24-441 Engineering Design II: Conceptualization and Realization or 24-671 Special Topics: Electromechanical Systems Design or 24-631 (spring only, starting Spring 2020). Students may take 24-441 or 24-671 in either fall or spring of senior year. BME and Robotics double majors/minors may use the capstone for their double major/minor instead of the above listed MechE capstone design classes.

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. 24-292 Renewable Energy Engineering is the only 200 level course that may be used as a Mechanical Engineering Technical Elective.
Students can also take 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. Undergraduates do not have priority for graduate level courses. Students can find a list of graduate courses we offer on the Carnegie Mellon Schedule of Classes https://enr-apps.as.cmu.edu/open/SOC/SOCServlet.

Course offerings are variable, please check the Schedule of Classes (above) to see the most current list of classes.

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 (including research institutes such as the Robotics Institute (http://www.ri.cmu.edu) and the Software Engineering Institute (http://www.sei.cmu.edu)). 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.

**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 2.0 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 core courses, the highest grade obtained between the original and the repeated class will be used to calculate the Mechanical Engineering QPA.

**Credit Overload Policy**

Mechanical Engineering students can register for a maximum of 54 units per semester. A student can request additional units from the Undergraduate Education Committee based on their QPA. The policy is outlined in the Mechanical Engineering Undergraduate Handbook at www.meche.engineering.cmu.edu/files/documents/handbooks/ug-handbook19.pdf.

**Double Majors and Minors**

Mechanical Engineering students may pursue double majors and minors in a variety of subjects, taking advantage of the free elective courses to satisfy the requirements for the major or minor. The College of Engineering has added designated minors to promote flexibility and diversity among engineering students. Common double majors for Mechanical Engineering students include Engineering and Public Policy, Biomedical Engineering and Robotics.

A complete description of majors and minors in engineering can be found on the College of Engineering website (https://engineering.cmu.edu/education/undergraduate-programs/curriculum/majors-minors.html).

**Internships and Co-operative Education Program**

The Mechanical Engineering Department considers experiential learning opportunities important educational options for its undergraduate students. Students in Mechanical Engineering are encouraged to undertake professional internships during summer breaks.

Another option is cooperative education, which provides a student with an extended period of exposure with a company. All co-ops must be at least 6 consecutive months in length, and must be a full-time, paid position with a single company.

**Study Abroad**

In today's global society, a study abroad experience can be an integral part of an undergraduate engineering education. An academic experience abroad is encouraged and assistance is provided for course choices and curriculum sequencing.

**Integrated Master's/Bachelor's Program (IMB)**

Interested undergraduates may plan a course of study that leads to both the Bachelor's and Master's in Mechanical Engineering. Beyond eight semesters, at least one semester of full-time graduate student status is required. Please refer to the Integrated Master's/Bachelor's Degree Program section in the Graduate Handbook for 2019-2020 (https://www.meche.engineering.cmu.edu/education/graduate-programs/handbooks.html) for additional information.

**Full-Time Faculty**

AMIR BARATI FARIMANI, Assistant Professor of Mechanical Engineering – Ph.D., University of Illinois at Urbana-Champaign; Carnegie Mellon, 2018–

MARK BEDIILLION, Associate Teaching Professor of Mechanical Engineering – Ph.D., Carnegie Mellon University; Carnegie Mellon, 2016–

SARAH BERGBREITER, Professor of Mechanical Engineering – Ph.D., University of California at Berkeley; Carnegie Mellon, 2018–

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

JONATHAN CAGAN, Interim Dean of the College of Engineering; George Tallman and Florence Barrett Ladd Professor of Engineering – Ph.D., University of California at Berkeley; Carnegie Mellon, 1990–

MAARTEN P. DE BOER, Professor of Mechanical Engineering – Ph.D., University of California at Berkeley; Carnegie Mellon, 2018–

NESTOR GOMEZ, Visiting Assistant Teaching Professor of Mechanical Engineering – Ph.D., Carnegie Mellon University; Carnegie Mellon, 2007–

DIANA HAIDAR, Assistant Teaching Professor of Mechanical Engineering – Ph.D., University of Delaware; Carnegie Mellon, 2017–

ENI HALILAJ, Assistant Professor of Mechanical Engineering – Ph.D., Brown University; Carnegie Mellon, 2018–

B. REEJA JAYAN, Assistant Professor of Mechanical Engineering – Ph.D., University of Texas at Austin; Carnegie Mellon, 2015–

AARON M. JOHNSON, Assistant Professor of Mechanical Engineering – Ph.D., University of Pennsylvania; Carnegie Mellon, 2016–

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


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

CARMEL MAJIDI, Associate Professor of Mechanical Engineering – Ph.D., University of California at Berkeley; Carnegie Mellon, 2011–

JONATHAN A. MALEN, Professor of Mechanical Engineering – Ph.D., University of California at Berkeley; Carnegie Mellon, 2009–

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

**Department of Mechanical Engineering**
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–

RAHUL PANAT, Associate Professor of Mechanical Engineering – Ph.D., University of Illinois at Urbana-Champaign; Carnegie Mellon, 2017–

ALBERT PRESTO, Associate 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, David and Susan Couter Head of Mechanical Engineering; Raymond J. Lane Distinguished Professor of Mechanical Engineering – Ph.D., University of California at Berkeley; Carnegie Mellon, 1998–

EDWARD STEPHEN RUBIN, Alumni Chair Professor of Environmental Engineering and Science – Ph.D., Stanford University; Carnegie Mellon, 1969–

SHENG SHEN, Associate 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, Associate Teaching Professor of Mechanical Engineering – Ph.D., University of Wisconsin at Madison; Carnegie Mellon, 2012–

PAUL S. STEIF, Associate Department Head and Professor of Mechanical Engineering – Ph.D., Harvard University; Carnegie Mellon, 1983–

RYAN SULLIVAN, Associate 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–

CONRAD TUCKER, Professor of Mechanical Engineering – Ph.D., University of Illinois at Urbana-Champaign; Carnegie Mellon, 2019–

VENKAT VISWANATHAN, Associate Professor of Mechanical Engineering – Ph.D., Stanford University; Carnegie Mellon, 2014–

VICTORIA WEBSTER-WOOD, Assistant Professor of Mechanical Engineering – Ph.D., Case Western Reserve University; Carnegie Mellon, 2018–

KATE S. WHITEFOOT, Assistant Professor of Mechanical Engineering – Ph.D., University of Michigan; Carnegie Mellon, 2016–

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

DING ZHAO, Assistant Professor of Mechanical Engineering – Ph.D., University of Michigan; Carnegie Mellon, 2018–

Emeriti

ADNAN AKAY, Lord Emeritus Professor of Mechanical Engineering – Ph.D., 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–

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