Department of Mechanical Engineering

Allen Robinson, Raymond J. Lane Distinguished Professor and Department Head
Scaife Hall 401
http://www.cmu.edu/me

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 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 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

<table>
<thead>
<tr>
<th>Fall</th>
<th>Units</th>
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</thead>
<tbody>
<tr>
<td>21-120 Differential and Integral Calculus</td>
<td>10</td>
</tr>
<tr>
<td>24-101 Fundamentals of Mechanical Engineering</td>
<td>12</td>
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<tr>
<td>33-141 Physics I for Engineering Students</td>
<td>12</td>
</tr>
<tr>
<td>99-101 Computing at Carnegie Mellon</td>
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<tr>
<td>76-101 Interpretation and Argument</td>
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<thead>
<tr>
<th>Spring</th>
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<tbody>
<tr>
<td>21-122 Integration and Approximation</td>
<td>10</td>
</tr>
<tr>
<td>xx-xxx  Second Introductory Engineering Course</td>
<td>12</td>
</tr>
<tr>
<td>xx-xxx Restricted Technical Elective 10-13</td>
<td>10</td>
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<tr>
<td>xx-xxx General Education Course</td>
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Sophomore Year

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<tbody>
<tr>
<td>21-259 Calculus in Three Dimensions</td>
<td>9</td>
</tr>
<tr>
<td>24-221 Thermodynamics I</td>
<td>10</td>
</tr>
<tr>
<td>24-261 Statics</td>
<td>10</td>
</tr>
<tr>
<td>xx-xxx Restricted Technical Elective 10-13</td>
<td>13</td>
</tr>
<tr>
<td>xx-xxx General Education Course</td>
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</tr>
<tr>
<td>24-200 Machine Shop Practice <em>Required sophomore year</em></td>
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<tr>
<td>39-210 Experiential Learning I</td>
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<tr>
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<tbody>
<tr>
<td>21-260 Differential Equations</td>
<td>9</td>
</tr>
<tr>
<td>24-231 Fluid Mechanics</td>
<td>10</td>
</tr>
<tr>
<td>24-262 Stress Analysis</td>
<td>12</td>
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<tr>
<td>xx-xxx Restricted Technical Elective 10-13</td>
<td>12</td>
</tr>
<tr>
<td>xx-xxx General Education Course</td>
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Junior Year

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<thead>
<tr>
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<th>Units</th>
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<tbody>
<tr>
<td>24-302 Mechanical Engineering Seminar I - taken either fall or spring</td>
<td>2</td>
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<tr>
<td>24-322 Heat Transfer</td>
<td>10</td>
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<tr>
<td>24-370 Engineering Design I: Methods and Skills</td>
<td>12</td>
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<tr>
<td>24-351 Dynamics</td>
<td>10</td>
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<tr>
<td>36-220 Engineering Statistics and Quality Control</td>
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<tr>
<td>xx-xxx  General Education Course</td>
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<tr>
<td>39-310 Experiential Learning III</td>
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<thead>
<tr>
<th>Spring</th>
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<tbody>
<tr>
<td>24-321 Thermal-Fluids Experimentation</td>
<td>12</td>
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<tr>
<td>24-311 Numerical Methods</td>
<td>12</td>
</tr>
<tr>
<td>24-352 Dynamic Systems and Controls</td>
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</tr>
<tr>
<td>xx-xxx General Education Course</td>
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Senior Year

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<tr>
<th>Fall</th>
<th>Units</th>
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</thead>
<tbody>
<tr>
<td>24-441 Engineering Design II: Conceptualization and Realization - required either fall or spring; alternate with xx-xxx 9 unit elective</td>
<td>12</td>
</tr>
<tr>
<td>24-452 Mechanical Systems Experimentation</td>
<td>9</td>
</tr>
<tr>
<td>xx-xxx Elective</td>
<td>9</td>
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<tr>
<td>xx-xxx Elective</td>
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<tr>
<td>xx-xxx General Education Course</td>
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<table>
<thead>
<tr>
<th>Spring</th>
<th>Units</th>
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</thead>
<tbody>
<tr>
<td>24-441 Engineering Design II: Conceptualization and Realization OR xx-xxx Elective</td>
<td>12</td>
</tr>
<tr>
<td>24-xxx Mechanical Engineering Technical Elective</td>
<td>9-12</td>
</tr>
<tr>
<td>xx-xxx Elective</td>
<td>9</td>
</tr>
<tr>
<td>xx-xxx Elective</td>
<td>9</td>
</tr>
<tr>
<td>xx-xxx General Education Course</td>
<td>9</td>
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<td>48-51</td>
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</tbody>
</table>

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. 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
Thermal-Fluid Systems

We require students to take at least one elective labeled as “Mechanical Engineering Technical Electives” 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. As previously mentioned, students cannot use these courses to fulfill the technical elective requirement.

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

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 Mechanical 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.

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
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. 

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/1bQGUy6rDtdRjoLmCnIFRF1kPCTMeXcmRmZjJtW2BNM/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 QPA.

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–.
KOUSHLIL SREEETH, 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–.


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–.