Department of Mechanical and Aerospace Engineering

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949-824-8451
http://mae.eng.uci.edu/

Overview
The Department of Mechanical and Aerospace Engineering offers two undergraduate B.S. programs: one in Mechanical Engineering and the other in Aerospace Engineering. The Department also offers M.S. and Ph.D. programs in Mechanical and Aerospace Engineering.

Mechanical Engineers and Aerospace Engineers design, manufacture, and control machines ranging from robots to aircraft and spacecraft, design engines and power plants that drive these machines, analyze the environmental impact associated with power generation, and strive to promote environmental quality. These disciplines require the creative use of mathematics, physics, and chemistry together with engineering science and technology in areas such as fluid mechanics, heat transfer, dynamics, controls, and atmospheric science to achieve these goals. Mechanical Engineering students and Aerospace Engineering at UCI learn the problem-solving, modeling, and testing skills required to contribute to be leaders in advancing modern technology and to be on the forefront of scientific discoveries.

The Mechanical Engineering undergraduate program includes required courses that provide engineering fundamentals and technical electives that allow students to study particular areas of interest. Elective courses can be organized into specializations in Aerospace Engineering, Energy Systems and Environmental Engineering, Flow Physics and Propulsion Systems, and Design of Mechanical Systems. Independent research opportunities allow students to pursue other avenues for focusing their studies.

Aerospace Engineering deals with all aspects of aircraft and spacecraft design and operation, thus requiring the creative use of many different disciplines. The undergraduate curriculum in Aerospace Engineering includes courses in subsonic and supersonic aerodynamics, propulsion, controls and performance, light-weight structures, spacecraft dynamics, and advanced materials. In the senior capstone course, students work in teams on the preliminary design of a commercial jet transport.

Career opportunities for Aerospace Engineering and Aerospace Engineering graduates are in a broad range of industries, including manufacturers of vehicles of all types, as well as aircraft and spacecraft, micro-mechanical systems, rehabilitation engineering, and research laboratories in universities and government.

On This Page:
- Aerospace Engineering
- Mechanical Engineering

Undergraduate Major in Aerospace Engineering

Program Educational Objectives: Graduates of the program will have the professional and scientific education that allows them to be successful as career engineers and in graduate programs. Specifically, they will be able to (1) function in professional environments in industry, government, and academia applying and building upon engineering science knowledge, problem-solving skills, and communication skills; (2) function as members of teams and in leadership roles applying ethical and inclusive standards including the AIAA code of ethics within and beyond traditional Aerospace Engineering disciplines; and (3) remain current with technology and contemporary scientific, environmental, and societal issues, and consequently improve skills and knowledge through a lifelong process of learning. (Program educational objectives are those aspects of engineering that help shape the curriculum; achievement of these objectives is a shared responsibility between the student and UCI.)

The undergraduate Aerospace Engineering curriculum includes a core of mathematics, physics, and chemistry. Engineering courses in fundamental areas constitute much of the remaining curriculum. A few technical electives allow the undergraduate student to specialize somewhat or to pursue broader understanding. A senior capstone design experience culminates the curriculum.

Admissions

High School Students: See School admissions information.

Transfer Students: Preference will be given to junior-level applicants with the highest grades overall, and who have satisfactorily completed the following required courses: two years of approved calculus, one year of calculus-based physics with laboratories (mechanics, electricity and magnetism), completion of lower-division writing, one course in general chemistry (with laboratory), statics, and one course in introductory programming. For course equivalency specific to each college, visit http://assist.org.
Students are encouraged to complete as many of the lower-division degree requirements as possible prior to transfer. Students who enroll at UCI in need of completing lower-division coursework may find that it will take longer than two years to complete their degrees. For further information, contact The Henry Samueli School of Engineering at 949-824-4334.

Requirements for the B.S. in Aerospace Engineering

All students must meet the University Requirements.

All students must meet the School Requirements.

Major Requirements

Mathematics and Basic Science Courses:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHEM 1A</td>
<td>General Chemistry</td>
</tr>
<tr>
<td>or ENGR 1A</td>
<td>General Chemistry for Engineers</td>
</tr>
<tr>
<td>CHEM 1LE</td>
<td>Accelerated General Chemistry Lab</td>
</tr>
<tr>
<td>MATH 2A-2B</td>
<td>Single-Variable Calculus and Single-Variable Calculus</td>
</tr>
<tr>
<td>MATH 2D</td>
<td>Multivariable Calculus</td>
</tr>
<tr>
<td>MATH 2E</td>
<td>Multivariable Calculus</td>
</tr>
<tr>
<td>MATH 3A</td>
<td>Introduction to Linear Algebra</td>
</tr>
<tr>
<td>MATH 3D</td>
<td>Elementary Differential Equations</td>
</tr>
<tr>
<td>PHYSICS 7C</td>
<td>Classical Physics</td>
</tr>
<tr>
<td>PHYSICS 7LC</td>
<td>Classical Physics Laboratory</td>
</tr>
<tr>
<td>PHYSICS 7D-7E</td>
<td>Classical Physics and Classical Physics</td>
</tr>
<tr>
<td>PHYSICS 7LD</td>
<td>Classical Physics Laboratory</td>
</tr>
<tr>
<td>PHYSICS 52A</td>
<td>Fundamentals of Experimental Physics</td>
</tr>
</tbody>
</table>

One additional General Education Category II course offered by the Schools of Physical Sciences, Biological Sciences, or Information and Computer Sciences.

Engineering Topics Courses:

Students must complete a minimum of 24 units of engineering design.

Core Courses:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENGR 54</td>
<td>Principles of Materials Science and Engineering</td>
</tr>
<tr>
<td>ENGRMAE 10</td>
<td>Introduction to Engineering Computations</td>
</tr>
<tr>
<td>ENGRMAE 30</td>
<td>Statics</td>
</tr>
<tr>
<td>ENGRMAE 60</td>
<td>Electric Circuits</td>
</tr>
<tr>
<td>or EECS 70A</td>
<td>Network Analysis I</td>
</tr>
<tr>
<td>ENGRMAE 80</td>
<td>Dynamics</td>
</tr>
<tr>
<td>ENGRMAE 91</td>
<td>Introduction to Thermodynamics</td>
</tr>
<tr>
<td>ENGRMAE 106</td>
<td>Mechanical Systems Laboratory</td>
</tr>
<tr>
<td>ENGRMAE 108</td>
<td>Aerospace Laboratory</td>
</tr>
<tr>
<td>ENGRMAE 112</td>
<td>Propulsion</td>
</tr>
<tr>
<td>ENGRMAE 130A</td>
<td>Introduction to Fluid Mechanics</td>
</tr>
<tr>
<td>ENGRMAE 130B</td>
<td>Introduction to Viscous and Compressible Flows</td>
</tr>
<tr>
<td>ENGRMAE 135</td>
<td>Compressible Flow</td>
</tr>
<tr>
<td>ENGRMAE 136</td>
<td>Aerodynamics</td>
</tr>
<tr>
<td>ENGRMAE 146</td>
<td>Astronautics</td>
</tr>
<tr>
<td>ENGRMAE 150</td>
<td>Mechanics of Structures</td>
</tr>
<tr>
<td>ENGRMAE 150L</td>
<td>Mechanics of Structures Laboratory</td>
</tr>
<tr>
<td>ENGRMAE 157</td>
<td>Lightweight Structures</td>
</tr>
<tr>
<td>ENGRMAE 158</td>
<td>Aircraft Performance</td>
</tr>
<tr>
<td>ENGRMAE 159</td>
<td>Aircraft Design</td>
</tr>
<tr>
<td>ENGRMAE 170</td>
<td>Introduction to Control Systems</td>
</tr>
<tr>
<td>ENGRMAE 175</td>
<td>Dynamics and Control of Aerospace Vehicles</td>
</tr>
</tbody>
</table>

Technical Elective Courses:
Students select a minimum of 12 units of technical electives. For students majoring in both Aerospace Engineering and Mechanical Engineering, a core course in one major cannot be counted as a technical elective in the other major. Any upper-division course in the department not used for the degree may be used as a technical elective. At least 4 units of technical electives must come from ENGRMAE upper-division courses and no more than 4 units of the technical electives should come from ENGRMAE 188, ENGRMAE 189, and ENGRMAE 199. With approval of the Undergraduate Advisor, students may choose from other departments’ upper-division courses that have primarily technical content. Preapproved courses are listed on the MAE website: http://engineering.uci.edu/files/mae-technical-electives.pdf

Engineering Professional Topics Course:
<table>
<thead>
<tr>
<th>Course</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECON 20A</td>
<td>Basic Economics I</td>
</tr>
<tr>
<td>or ECON 23</td>
<td>Basic Economics for Engineers</td>
</tr>
<tr>
<td>ENGR 190W</td>
<td>Communications in the Professional World</td>
</tr>
</tbody>
</table>

At most an aggregate total of 4 units of 199 or H199 courses may be used to satisfy degree requirements.

(The nominal Aerospace Engineering program will require 185 units of courses to satisfy all university and major requirements. Because each student comes to UCI with a different level of preparation, the actual number of units will vary.)

Design unit values are indicated at the end of each course description. The faculty advisors and the Undergraduate Student Affairs Office can provide necessary guidance for satisfying the design requirements. Selection of elective courses must be approved by the student’s faculty advisor and the departmental undergraduate advisor.

Program of Study

Sample Program of Study — Aerospace Engineering

<table>
<thead>
<tr>
<th>Program</th>
<th>Winter</th>
<th>Spring</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Freshman</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fall</td>
<td>Winter</td>
<td>Spring</td>
</tr>
<tr>
<td>MATH 2A</td>
<td>MATH 2B</td>
<td>MATH 2D</td>
</tr>
<tr>
<td>ENGRMAE 10</td>
<td>PHYSICS 7C</td>
<td>PHYSICS 7D</td>
</tr>
<tr>
<td>CHEM 1A or ENGR 1A</td>
<td>ENGRMAE 7LC</td>
<td>ECON 23 or 20A</td>
</tr>
<tr>
<td>ENGR 7A</td>
<td>CHEM 1LE</td>
<td>Basic Science</td>
</tr>
<tr>
<td>General Education</td>
<td>ENGR 7B</td>
<td>General Education</td>
</tr>
</tbody>
</table>

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| | | | | |
| | | | | |
| **Sophomore** | | | |
| Fall | Winter | Spring |
| MATH 3A | MATH 3D | MATH 2E |
| PHYSICS 7E | ENGR 54 | ENGRMAE 91 |
| PHYSICS 52A | ENGRMAE 60 | ECON 23 or 20A |
| ENGRMAE 30 | ENGRMAE 80 | |
| General Education | | |

| | | | | |
| | | | | |
| | | | | |
| **Junior** | | | |
| Fall | Winter | Spring |
| ENGRMAE 130A | ENGRMAE 130B | ENGRMAE 106 |
| ENGRMAE 150 | ENGRMAE 146 | ENGRMAE 108 |
| ENGRMAE 150L | ENGRMAE 157 | ENGRMAE 135 |
| ENGR 190W | General Education | General Education |

| | | | | |
| | | | | |
| | | | | |
| **Senior** | | | |
| Fall | Winter | Spring |
| ENGRMAE 112 | ENGRMAE 158 | ENGRMAE 159 |
| ENGRMAE 136 | ENGRMAE 175 | Technical Elective |
| ENGRMAE 170 | Technical Elective | Technical Elective |
| General Education | General Education | General Education |

*ENGR 7A-ENGR 7B is a technical elective, available only to lower-division students in Fall and Winter quarters. Both ENGR 7A & ENGR 7B must be taken to count as a technical elective. If ENGR 7A-ENGR 7B is taken, this will replace one technical elective course in the senior year.

The sample program of study chart shown is typical for the major in Aerospace Engineering. This program is based upon a set of prerequisites, beginning with adequate preparation in high school mathematics, physics, and chemistry. Students should consult with their academic counselor to structure their program of study. Aerospace Engineering majors are encouraged to consult with academic counselors as needed, and students who are academically at risk are mandated to see a counselor as frequently as deemed necessary by the advising staff.

Undergraduate Major in Mechanical Engineering

Program Educational Objectives: Graduates of the program will have the professional and scientific education that allows them to be successful as career engineers and in graduate programs. Specifically, they will be able to (1) function in professional environments in industry, government, and
academia applying and building upon engineering science knowledge, problem-solving skills, and communication skills; (2) function as members of teams and in leadership roles applying ethical and inclusive standards including the ASME code of ethics within and beyond traditional Mechanical Engineering disciplines; and (3) remain current with technology and contemporary scientific, environmental and societal issues, and consequently improve skills and knowledge through a lifelong process of learning. (Program educational objectives are those aspects of engineering that help shape the curriculum; achievement of these objectives is a shared responsibility between the student and UCI.)

The undergraduate Mechanical Engineering curriculum includes a foundation of mathematics, physics, and chemistry. Engineering courses in fundamental areas constitute much of the remaining curriculum. A few technical electives allow undergraduate students to specialize in Aerospace Engineering, Energy Systems and Environmental Engineering, Flow Physics and Propulsion Systems, and Design of Mechanical Systems or to pursue broader understanding in these areas. A senior capstone design experience culminates the curriculum.

Admissions
High School Students: See School Admissions information.

Transfer Students: Preference will be given to junior-level applicants with the highest grades overall, and who have satisfactorily completed the following required courses: two years of approved calculus, one year of calculus-based physics with laboratories (mechanics, electricity and magnetism), completion of lower-division writing, one course in general chemistry (with laboratory), one course in introductory programming, statics, and engineering graphics.

Students are encouraged to complete as many of the lower-division degree requirements as possible prior to transfer. Students who enroll at UCI in need of completing lower-division coursework may find that it will take longer than two years to complete their degrees. For further information, contact The Henry Samueli School of Engineering at 949-824-4334.

Requirements for the B.S. in Mechanical Engineering
All students must meet the University Requirements.
All students must meet the School Requirements.

Major Requirements
Mathematics and Basic Science Courses:

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<td>MATH 3A</td>
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<td>MATH 3D</td>
<td>Elementary Differential Equations</td>
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One additional General Education Category II course offered by the Schools of Physical Sciences, Biological Sciences, or Information and Computer Sciences.

Engineering Topics Courses:
Students must complete a minimum of 24 units of engineering design.

Core Courses:

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<td>Introduction to Engineering Computations</td>
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<tr>
<td>ENGRMAE 30</td>
<td>Statics</td>
</tr>
<tr>
<td>ENGRMAE 52</td>
<td>Computer-Aided Design</td>
</tr>
<tr>
<td>ENGRMAE 60</td>
<td>Electric Circuits</td>
</tr>
<tr>
<td>or EECS 70A</td>
<td>Network Analysis I</td>
</tr>
<tr>
<td>ENGRMAE 80</td>
<td>Dynamics</td>
</tr>
<tr>
<td>ENGRMAE 91</td>
<td>Introduction to Thermodynamics</td>
</tr>
</tbody>
</table>
ENGRMAE 106  Mechanical Systems Laboratory
ENGRMAE 107  Fluid Thermal Science Laboratory
ENGRMAE 112  Propulsion
or ENGRMAE 115  Applied Engineering Thermodynamics
ENGRMAE 120  Heat and Mass Transfer
ENGRMAE 130A  Introduction to Fluid Mechanics
ENGRMAE 130B  Introduction to Viscous and Compressible Flows
ENGRMAE 145  Theory of Machines and Mechanisms
ENGRMAE 147  Vibrations
ENGRMAE 150  Mechanics of Structures
ENGRMAE 150L  Mechanics of Structures Laboratory
ENGRMAE 151  Mechanical Engineering Design
ENGRMAE 155  Composite Materials and Structures
or ENGRMAE 156  Mechanical Behavior and Design Principles
or ENGRMAE 157  Lightweight Structures
ENGRMAE 170  Introduction to Control Systems
ENGRMAE 189  Senior Project - Special Topics (minimum of 3 units)

Technical Elective Courses:

Students select a minimum of 16 units of technical electives. For students majoring in both Aerospace Engineering and Mechanical Engineering, a core course in one major cannot be counted as a technical elective in the other major. Any upper-division course in the department not used for the degree may be used as a technical elective. At least 8 units of the technical electives must come from ENGRMAE upper-division courses other than project-based courses ENGRMAE 188, ENGRMAE 189, and ENGRMAE 199. With approval of the Undergraduate Advisor, students may choose any remaining technical elective units from other departments' upper-division courses that have primarily technical content. Preapproved courses from other departments are listed on the MAE website: http://engineering.uci.edu/files/mae-technical-electives.pdf

Engineering Professional Topics Course:

ECON 20A  Basic Economics I
or ECON 23  Basic Economics for Engineers
ENGR 190W  Communications in the Professional World

At most an aggregate total of 4 units of 199 or H199 courses may be used to satisfy degree requirements.

(The nominal Mechanical Engineering program will require 188 units of courses to satisfy all university and major requirements. Because each student comes to UCI with a different level of preparation, the actual number of units will vary.)

Specialization in Aerospace Engineering:

Completion of a Senior Design Project in this area, and select two of the following:

ENGRMAE 112  Propulsion
ENGRMAE 135  Compressible Flow
ENGRMAE 136  Aerodynamics
ENGRMAE 158  Aircraft Performance
ENGRMAE 159  Aircraft Design
ENGRMAE 175  Dynamics and Control of Aerospace Vehicles

Specialization in Energy Systems and Environmental Engineering:

Completion of a Senior Design Project in this area, and select two of the following:

ENGRMAE 110  Combustion and Fuel Cell Systems
ENGRMAE 112  Propulsion
ENGRMAE 114  Fuel Cell Fundamentals and Technology
ENGRMAE 115  Applied Engineering Thermodynamics
ENGRMAE 117  Solar and Renewable Energy Systems
ENGRMAE 118  Sustainable Energy Systems
ENGRMAE 164  Air Pollution and Control

Specialization in Flow Physics and Propulsion Systems:

Completion of a Senior Design Project in this area, and
select two of the following:

ENGRMAE 110  Combustion and Fuel Cell Systems
ENGRMAE 112  Propulsion
ENGRMAE 113  Electric Propulsion
ENGRMAE 135  Compressible Flow

Specialization in Design of Mechanical Systems:
Completion of a Senior Design Project in this area, and
select two of the following:

ENGR 165  Advanced Manufacturing
ENGRMAE 152  Introduction to Computer-Aided Engineering
ENGRMAE 171  Digital Control Systems
ENGRMAE 172  Design of Computer-Controlled Robots
ENGRMAE 183  Computer-Aided Mechanism Design
ENGRMAE 188  Engineering Design in Industry

Design unit values are indicated at the end of each course description. The faculty advisors and the Student Affairs Office can provide necessary guidance for satisfying the design requirements. Selection of elective courses must be approved by the student’s faculty advisor and the departmental undergraduate advisor.

Program of Study
Sample Program of Study — Mechanical Engineering

Freshman

<table>
<thead>
<tr>
<th>Fall</th>
<th>Winter</th>
<th>Spring</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH 2A</td>
<td>MATH 2B</td>
<td>MATH 2D</td>
</tr>
<tr>
<td>ENGRMAE 10</td>
<td>PHYSICS 7C</td>
<td>PHYSICS 7D</td>
</tr>
<tr>
<td>CHEM 1A or ENGR 1A</td>
<td>PHYSICS 7LC</td>
<td>PHYSICS 7LD</td>
</tr>
<tr>
<td>ENGR 7A</td>
<td>CHEM 1LE</td>
<td>Basic Science</td>
</tr>
<tr>
<td>General Education</td>
<td>ENGR 7B*</td>
<td>General Education</td>
</tr>
</tbody>
</table>

Sophomore

<table>
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<tr>
<th>Fall</th>
<th>Winter</th>
<th>Spring</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH 3A</td>
<td>MATH 3D</td>
<td>MATH 2E</td>
</tr>
<tr>
<td>PHYSICS 7E</td>
<td>ENGR 54</td>
<td>ENGRMAE 52</td>
</tr>
<tr>
<td>PHYSICS 52A</td>
<td>ENGRMAE 60</td>
<td>ENGRMAE 91</td>
</tr>
<tr>
<td>ENGRMAE 30</td>
<td>ENGRMAE 80</td>
<td>ECON 23 or 20A</td>
</tr>
<tr>
<td>General Education</td>
<td>ENGRMAE 7B*</td>
<td>General Education</td>
</tr>
</tbody>
</table>

Junior

<table>
<thead>
<tr>
<th>Fall</th>
<th>Winter</th>
<th>Spring</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENGRMAE 115 or 112</td>
<td>ENGRMAE 130B</td>
<td>ENGRMAE 106</td>
</tr>
<tr>
<td>ENGRMAE 130A</td>
<td>ENGRMAE 147</td>
<td>ENGRMAE 120</td>
</tr>
<tr>
<td>ENGRMAE 150</td>
<td>ENGRMAE 156, 155, or 157</td>
<td>ENGRMAE 145</td>
</tr>
<tr>
<td>ENGRMAE 150L</td>
<td>General Education</td>
<td>General Education</td>
</tr>
<tr>
<td>ENGR 190W</td>
<td>General Education</td>
<td>General Education</td>
</tr>
</tbody>
</table>

Senior

<table>
<thead>
<tr>
<th>Fall</th>
<th>Winter</th>
<th>Spring</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENGRMAE 107</td>
<td>ENGRMAE 151</td>
<td>ENGRMAE 189</td>
</tr>
<tr>
<td>ENGRMAE 170</td>
<td>Technical Elective*</td>
<td>Technical Elective</td>
</tr>
<tr>
<td>General Education</td>
<td>Technical Elective</td>
<td>General Education</td>
</tr>
</tbody>
</table>

*ENGR 7A-ENGR 7B is a technical elective, available only to lower-division students in Fall and Winter quarters. Both ENGR 7A & ENGR 7B must be taken to count as a technical elective. If ENGR 7A-ENGR 7B is taken, this will replace one technical elective course in the senior year.

The sample program of study chart shown is typical for the accredited major in Mechanical Engineering. Students should keep in mind that this program is based upon a rigid set of prerequisites, beginning with adequate preparation in high school mathematics, physics, and chemistry. Students should consult with their academic counselor to structure their program of study. Mechanical Engineering majors are encouraged to consult with academic counselors as needed, and students who are academically at risk are mandated to see a counselor as frequently as deemed necessary by the advising staff.
ENGRMAE 155 may be used instead of ENGRMAE 156 or ENGRMAE 157. Students can dual major in Mechanical Engineering and Aerospace Engineering by satisfying the degree requirements for both majors.

On This Page:

- Mechanical and Aerospace Engineering
- Master of Science Degree
- Doctor of Philosophy Degree

### Graduate Study in Mechanical and Aerospace Engineering

The Mechanical and Aerospace Engineering faculty have special interest and expertise in four thrust areas: continuum mechanics; power, propulsion, and environment; micro/nanomechanics; and systems and design.

Continuum mechanics faculty study the physics of fluids, physics and chemistry of solids, and structural mechanics. Areas of emphasis in fluid mechanics include incompressible and compressible turbulent flows, multiphase flows, chemically reacting and other nonequilibrium flows, aeroacoustics, aerooptics, and fluid-solid interaction. In the field of solid mechanics, research and course work emphasize theoretical and computational approaches which contribute to a basic understanding of and new insight into the properties and behavior of condensed matter. General areas of interest are large-strain and large-rotation inelastic solids, constitutive modeling, and fracture mechanics. Computational algorithms center on boundary element methods and the new class of meshless methods. Studies in structural mechanics involve the analysis and synthesis of low-mass structures, smart structures, and engineered materials, with emphasis on stiffness, stability, toughness, damage tolerance, longevity, optimal life-cycle costs and self-adaptivity.

Research in power, propulsion, and environment encompasses aerospace propulsion, combustion and thermophysics, fuel cell technologies, and atmospheric physics and impacts. In aerospace propulsion, particular emphasis is placed in the areas of turbomachinery, spray combustion, combustion instability, innovative engine cycles, and compressible turbulent mixing. The topic of combustion and thermophysics addresses the fundamental fluid-dynamical, heat-transfer, and chemical mechanisms governing combustion in diverse settings. Fuel cell research encompasses the development of fuel-cell technology, hybrid engines, and thermionic devices. Activities cover the thermodynamics of energy systems, the controls associated with advanced energy systems, and systems analyses. The area of atmospheric physics and impacts deals with the modeling and controlling of chemical pollution, particle dispersion, and noise emission caused by energy-generation and propulsion devices. Research on atmospheric turbulence addresses the energy exchanges between the Earth’s land and ocean surfaces and the overlying atmosphere. Micro/nanomechanics encompasses the thrusts of miniaturization engineering, mechatronics, and biotechnology. Miniaturization engineering is relevant to the development of small-scale mechanical, chemical and biological systems for applications in biotechnology, automotive, robotic, and alternative energy applications. It involves the establishment of scaling laws, manufacturing methods, materials options and modeling from the atom to the macrosystem. Mechatronic design is the integrated and optimal design of a mechanical system and its embedded control system. Main focus research is the design, modeling, and characterization of Micro Electro Mechanical Systems (MEMS). Particular emphasis is placed on analysis and design of algorithmic methods and physical systems that realize sensor-based motion planning. The thematic area of biotechnology involves the understanding, modeling, and application of fundamental phenomena in mechanical engineering, electrical engineering, and chemistry towards the development of bio-sensors and actuators.

Systems and design research is conducted in the areas of dynamic systems optimization and control, biomechanical engineering, robotics and machine learning, and design engineering. Advanced concepts in dynamics, optimization and control are applied to the areas of biorobotics, flight trajectory design, guidance and navigation, learning systems, micro sensors and actuators, flexible structures, combustion, fuel cells, and fluid-optical interactions.

Biomechanical engineering integrates physiology with engineering in order to develop innovative devices and algorithms for medical diagnosis and treatment. The focus of robotics and machine learning is the creation of machines with human-like intelligence capabilities for learning. Faculty in design engineering develop methodologies to address issues ranging from defining the size and shape of components needed for force and motion specifications, to characterizing performance in terms of design parameters, cost and complexity.

Aerospace engineering research efforts combine specialties from each of the four thrust areas toward the design, modeling, and operation of complex systems.

The Department offers the M.S. and Ph.D. degrees in Mechanical and Aerospace Engineering.

### Master of Science Degree

Two plans are available to pursue study toward the M.S.: a thesis option and a comprehensive examination option. Opportunities are available for part-time study toward the M.S. The Plan of Study for both options must be developed in consultation with a Faculty Advisor and approved by the Department Graduate Advisor. Opportunities to pursue teaching experiences and to take a course to develop teaching excellence are also offered, and may be integrated into your plan of study.

**Plan I: Thesis Option**

The thesis option requires completion of eight graduate, technical and science courses; the completion of an original research project with a Faculty Advisor, the writing of the thesis describing it; and approval of the thesis by a thesis committee. This plan is available for those who wish to gain research experience or as preparation for study toward the doctoral degree. Students must complete 12 units of ENGRMAE 296, 3 units...
of ENGRMAE 298, and four graduate courses from a restricted list in the selected major. Additionally, four of the eight required graduate courses must be from the MAE Department. With the approval of the graduate advisor, one non-core graduate course may be replaced by an upper-division undergraduate course in MAE; this course may not have been used to satisfy the undergraduate degree requirements.

NOTE: Students who enter prior to fall of 2008 should follow the course requirements outlined within the Catalogue of the year they entered. The change in number of units per course is not intended to change the course requirements for the degree or to have any impact in the number of courses students are taking. As such, students will need to continue to meet the same high standards and plan of study requirements as previously required. Students will work with their advisor to create a plan of study encompassing the equivalent topical requirements, as well as the equivalent number of courses to the previous 36 unit requirement (i.e., at least 8 graduate-level courses to meet the 24, 200–289 level unit requirement).

Plan II: Comprehensive Examination Option
The comprehensive examination option requires completion of eleven graduate, technical and science courses, plus a comprehensive exam. Students must complete 3 units of ENGRMAE 298 and four graduate courses from a restricted list. Additionally, six of the eleven required graduate courses must be from the MAE Department. Up to two of the required courses may be replaced by an equivalent number of units of ENGRMAE 294, which includes execution and documentation of a research or design project under a faculty advisor. With the approval of the graduate advisor, one graduate course may be replaced by an upper-division undergraduate course in MAE; this course may not be used to satisfy both undergraduate and graduate degree requirements. Consult the MAE Department (http://mae.eng.uci.edu) website (http://mae.eng.uci.edu) or Graduate Advisor, for detailed information on the comprehensive exam.

NOTE: Students who entered prior to fall of 2008 should follow the course requirements outlined within the Catalogue of the year they entered. The change in number of units per course is not intended to change the course requirements for the degree or to have any impact in the number of courses students are taking. As such, students will need to continue to meet the same high standards and plan of study requirements as previously required. Students will work with their advisor to create a plan of study encompassing the equivalent topical requirements, as well as the equivalent number of courses to the previous 36 unit requirement (i.e., at least 11 graduate-level courses to meet the 33, 200–289 level unit requirement).

Doctor of Philosophy Degree
The doctoral program in Mechanical and Aerospace Engineering is tailored to the individual needs and background of the student. The detailed program of study for each Ph.D. student is formulated in consultation with a faculty advisor who takes into consideration the objectives and preparation of the candidate.

Within this flexible framework the Department maintains specific guidelines that outline the milestones of a typical doctoral program. All doctoral students should consult the Departmental Ph.D. guidelines for program details, but there are several milestones to be passed: admission to the Ph.D. program by the faculty; completion of three non-research graduate, technical courses beyond M.S. degree requirements; passage of a preliminary examination or similar assessment of the student's background and potential for success in the doctoral program; course work; meeting departmental teaching requirements, which can be satisfied through service as a teaching assistant or equivalent; research preparation; formal advancement to candidacy in the third year (second year for students who entered with a master's degree) through a qualifying examination conducted on behalf of the Irvine division of the Academic Senate; development of a research proposal; completion of a significant research investigation, and completion and defense of an acceptable dissertation. There is no foreign language requirement. The degree is granted upon the recommendation of the Doctoral Committee and the Dean of Graduate Studies. Students enrolled in the Ph.D. program must take a full-time load (minimum of 12 units). The normative time for completion of the Ph.D. is five years (four years for students who entered with a master's degree). The maximum time permitted is seven years. Before seeking admission, Ph.D. applicants are encouraged to communicate directly and in some detail with prospective faculty sponsors. The student's objectives and financial resources must coincide with a faculty sponsor's research interests and research support. Financial aid in the form of a teaching assistantship or fellowship may not cover the period of several years required to complete the program. During the balance of the period the student will be in close collaboration with the faculty research advisor.

Faculty
Satya N. Atluri, ScD Massachusetts Institute of Technology, Professor Emeritus of Mechanical and Aerospace Engineering
James E. Bobrow, Ph.D. University of California, Los Angeles, Professor Emeritus of Mechanical and Aerospace Engineering (robotics, mechatronics, and design optimization)
Jacob Brouwer, Ph.D. Massachusetts Institute of Technology, Professor of Mechanical and Aerospace Engineering; Civil and Environmental Engineering (fuel cells, energy systems dynamics, electrochemical systems design and analysis, chemical kinetics, reacting flows)
Natascha Buswell, Ph.D. Purdue University, Assistant Professor of Teaching of Mechanical and Aerospace Engineering (graduate engineering education, faculty development, engineering teaching, engineering education research methods)
Penghui Cao, Ph.D. Boston University, Assistant Professor of Mechanical and Aerospace Engineering (mechanics of amorphous solids; creep and deformation mechanisms, materials in extreme environments, radiation damage, long timescale atomistic simulation)
Donald Dabdub, Ph.D. California Institute of Technology, Associate Dean, Undergraduate Education and Professor of Mechanical and Aerospace Engineering; Civil and Environmental Engineering (mathematical modeling of urban and global air pollution, dynamics of atmospheric aerosols, secondary organic aerosols, impact of energy generation on air quality, chemical reactions at gas-liquid interfaces)

Derek Dunn-Rankin, Ph.D. University of California, Berkeley, Department Chair and Professor of Mechanical and Aerospace Engineering; Civil and Environmental Engineering; Environmental Health Sciences (combustion, optical particle sizing, particle aerodynamics, laser diagnostics and spectroscopy)

Said E. Elghobashi, Ph.D. University of London, Distinguished Professor Emeritus of Mechanical and Aerospace Engineering (direct numerical simulation of turbulent, chemically reacting and dispersed two-phase flows)

Manuel Gamero-Castaño, Ph.D. Yale University, Associate Professor of Mechanical and Aerospace Engineering (electric propulsion, with emphasis on colloid thruster technology for precision formation flying missions and Hall thrusters. Electrohydrodynamic atomization of liquids and related problems like electrospray ionization and technological applications of electrosprays, aerosol diagnostics)

Tyrphon Georgiou, Ph.D. University of Florida, Distinguished Professor of Mechanical and Aerospace Engineering (dynamical systems and control, mathematical physics, applied mathematics. Current interests focus on stochastic control, geometry of optimal mass transport, inverse problems in physics and signal analysis, and topics related to the control of fluids, networks and thermodynamic systems)

Faryar Jabbari, Ph.D. University of California, Los Angeles, Associate Dean for Academic Affairs and Professor of Mechanical and Aerospace Engineering (control theory and applications, saturation control)

Zak Kassas, Ph.D. University of Texas at Austin, Assistant Professor of Mechanical and Aerospace Engineering; Electrical Engineering and Computer Science (cyber-physical systems (CPS), autonomous vehicles (aerial, ground, indoor, underwater), satellite-based navigation, intelligent transportation systems (ITS), cognitive and software-defined radio (SDR), sensor fusion)

Selmaz S. Xia, Ph.D. University of California, Irvine, Assistant Professor of Mechanical and Aerospace Engineering; Computer Science (systems and control, decentralized/distributed algorithm design for multi-agent systems, cooperative robotics, cooperative navigation, pedestrian localization, localization in GPS-denied environments)

John C. Larue, Ph.D. University of California, San Diego, Professor Emeritus of Mechanical and Aerospace Engineering (fluid mechanics, heat transfer, turbulence)

Jaeho Lee, Ph.D. Stanford University, Assistant Professor of Mechanical and Aerospace Engineering (heat transfer, thermal management, thermoelectrics, phononics, nanomaterials)

Robert Liebeck, Ph.D. University of Illinois at Urbana-Champaign, Adjunct Professor of Mechanical and Aerospace Engineering (aerodynamics, hydrodynamics, aircraft design)

Feng Liu, Ph.D. Princeton University, Professor of Mechanical and Aerospace Engineering (computational fluid dynamics, turbomachinery, propulsion)

Marc J. Madou, Ph.D. Ghent University, UCI Chancellor's Professor of Mechanical and Aerospace Engineering; Biomedical Engineering; Chemical and Biomolecular Engineering (miniaturization science (MEMS and NEMS) with emphasis on chemical and biological applications)

J. Michael McCarthy, Ph.D. Stanford University, Director of the Performance Engineering Program and Professor of Mechanical and Aerospace Engineering (design of mechanical systems, computer aided design, kinematic theory of spatial motion)

Vincent G. McDonell, Ph.D. University of California, Irvine, Adjunct Professor of Mechanical and Aerospace Engineering (combustion, alternative fuels, gas turbines, sprays, diagnostics, combined heat and power, emissions, autoignition/flashback)

Kenneth D. Mease, Ph.D. University of Southern California, Professor Emeritus of Mechanical and Aerospace Engineering (nonlinear dynamics and control; flight guidance and control)

Lawrence Muzio, Ph.D. University of California, Berkeley, Adjunct Professor of Mechanical and Aerospace Engineering (thermodynamics, combustion and combustion in practical systems, air pollution formation and control, advanced diagnostics applied to practical combustion systems)

Bhiter Padak, Ph.D. Stanford University, Assistant Professor of Mechanical and Aerospace Engineering; Chemical and Biomolecular Engineering

Dimitri Papamoschou, Ph.D. California Institute of Technology, Professor of Mechanical and Aerospace Engineering (compressible turbulence, jet and fan aeroacoustics, jet noise reduction, mixing enhancement, microphone phased array methods)

Edwin Peraza Hernandez, Ph.D. Texas A&M University, Assistant Professor of Mechanical and Aerospace Engineering (morphing structures, deployable structures, origami, tensegrity, active materials, structural optimization)

Roger H. Rangel, Ph.D. University of California, Berkeley, Professor of Mechanical and Aerospace Engineering (heat transfer, fluid mechanics, two-phase flows, fluid instability and atomization)
G. Scott Samuelsen, Ph.D. University of California, Berkeley, Director of Advanced Power and Energy Program, Research Professor and Professor Emeritus of Mechanical and Aerospace Engineering; Civil and Environmental Engineering (energy systems, fuel cells, combustion, sprays, laser diagnostics, air quality, turbulent transport, alternative fuels, modeling reacting flows, practical systems, energy and environmental conflict)

William E. Schmitendorf, Ph.D. Purdue University, Professor Emeritus of Mechanical and Aerospace Engineering (control theory and applications)

Andrei M. Shkel, Ph.D. University of Wisconsin-Madison, Professor of Mechanical and Aerospace Engineering; Biomedical Engineering; Electrical Engineering and Computer Science (design and advanced control of micro-electro-mechanical systems (MEMS); high precision micro-machined gyroscopes; MEMS-enhanced optical systems, tools and prosthetic appliances; electromechanical and machine-information systems integration)

Athanasios Sideris, Ph.D. University of Southern California, Professor of Mechanical and Aerospace Engineering (control systems, neural networks)

William A. Sirignano, Ph.D. Princeton University, Henry Samueli Endowed Chair in Engineering and Distinguished Professor of Mechanical and Aerospace Engineering (combustion theory, multiphase flows, turbulent reacting flows, computational methods, rocket and jet propulsion, and gas turbine engines)

Haiithem Taha, Ph.D. Virginia Polytechnic Institute and State University, Assistant Professor of Mechanical and Aerospace Engineering (geometric nonlinear control theory; unsteady aerodynamics and aeroelasticity; optimization, calculus of variations and optimal control; flight dynamics and autopilot design; airplane performance and configuration aerodynamics)

Mark Walter, Ph.D. California Institute of Technology, Associate Professor of Teaching of Mechanical and Aerospace Engineering (mechanics of multifunctional materials, building energy efficiency)

Yoon Jin Won, Ph.D. Pennsylvania State University, Professor of Mechanical and Aerospace Engineering (fuel cells, computational modeling, thermofluidics, two-phase flows, electrochemistry, Computational Fluid Dynamics (CFD), turbulent combustion)

Gregory N. Washington, Ph.D. North Carolina State University at Raleigh, Stacy Nicholas Dean of The Henry Samueli School of Engineering and Professor of Mechanical and Aerospace Engineering (dynamic systems with emphasis on modeling and control of smart material systems and devices)

Yoon Jin Won, Ph.D. Stanford University, Assistant Professor of Mechanical and Aerospace Engineering (multi-scale structures for thermal and energy applications, in particular fabrication, characterization, and integration of structured materials)

Affiliate Faculty

Mohammad A. Al Faruque, Ph.D. University of Kaiserslautern, Chair of Emulex Career Development and Associate Professor of Electrical Engineering and Computer Science; Mechanical and Aerospace Engineering (system-level design, embedded systems, cyber-physical-systems, multi-core systems)

Aparna Chandramowlishwaran, Ph.D. Georgia Institute of Technology, Assistant Professor of Electrical Engineering and Computer Science; Computer Science; Mechanical and Aerospace Engineering (high-performance computing, domain-specific compilers, algorithm-architecture co-design, data analysis, and scientific computing)

Joyce H. Keyak, Ph.D. University of California, San Francisco, Professor in Residence of Radiological Sciences; Biomedical Engineering; Mechanical and Aerospace Engineering

Arash Kheradvar, Ph.D. California Institute of Technology, Professor of Biomedical Engineering; Mechanical and Aerospace Engineering (cardiac mechanics, cardiovascular devices, cardiac imaging)

Abraham P. Lee, Ph.D. University of California, Berkeley, William J. Link Chair in Biomedical Engineering and Professor of Biomedical Engineering; Mechanical and Aerospace Engineering (integrated point-of-care diagnostics, engineered "theranostic" vesicles and particles, active cell sorting microdevices, microphysiological microsystems, and high throughput droplet bioassays)

Beth A. Lopour, Ph.D. University of California, Berkeley, Assistant Professor of Biomedical Engineering; Mechanical and Aerospace Engineering (computational neuroscience, signal processing, mathematical modeling, epilepsy, translational research)

David J. Reinkensmeyer, Ph.D. University of California, Berkeley, Professor of Anatomy and Neurobiology; Biomedical Engineering; Mechanical and Aerospace Engineering; Physical Medicine and Rehabilitation

Timothy Rupert, Ph.D. Massachusetts Institute of Technology, Associate Professor of Materials Science and Engineering; Chemical and Biomolecular Engineering; Mechanical and Aerospace Engineering (mechanical behavior, nanomaterials, structure property relationships, microstructural stability, grain boundaries and interfaces, materials characterization)

Lorenzo Valdevit, Ph.D. Princeton University, Director of Institute for Design and Manufacturing Innovation (IDMI) and Associate Professor of Materials Science and Engineering; Mechanical and Aerospace Engineering (architected materials, mechanical metamaterials, additive manufacturing, optimal design)
Courses

ENGRMAE 10. Introduction to Engineering Computations. 4 Units.
Introduction to the solution of engineering problems through the use of the computer. Elementary programming, numerical analysis, and data visualization with a high-level programming language such as MATLAB.

(Design units: 1)
Corequisite: MATH 2A
Prerequisite: MATH 2A or MATH 5A
Overlaps with EECS 10, EECS 12, BME 60B.
Restriction: Mechanical Engineering Majors have first consideration for enrollment. Aerospace Engineering Majors have first consideration for enrollment. Chemical Engineering Majors have first consideration for enrollment. Materials Science Engineering Majors have first consideration for enrollment.

ENGRMAE 30. Statics. 4 Units.
Addition and resolution of forces, distributed forces, equivalent system of forces centroids, first moments, moments and products on inertia, equilibrium of rigid bodies, trusses, beams, cables. Course may be offered online.

(Design units: 0)
Corequisite: MATH 2D
Prerequisite: MATH 2D and PHYSICS 7C
Same as ENGRCEE 30, ENGR 30.
Restriction: School of Engineering students have first consideration for enrollment.

ENGRMAE 52. Computer-Aided Design. 4 Units.
Develops skills for interpretation and presentation of mechanical design drawings and the use of CAD in engineering design. An integrated approach to drafting based on sketching, manual drawing, and three-dimensional CAD techniques is presented.

(Design units: 0.5)
Restriction: Mechanical Engineering Majors have first consideration for enrollment. Materials Science Engineering Majors have first consideration for enrollment.

ENGRMAE 57. Manufacturing Processes in Engineering. 2 Units.

(Design units: 0)
Grading Option: Pass/no pass only.
Restriction: School of Engineering students have first consideration for enrollment.
ENGRMAE 60. Electric Circuits. 4 Units.
Design and analysis of analog circuits based on lumped circuit elements with emphasis on the use of operational amplifiers. Sinusoidal and transient response. Constructional and laboratory testing of analog circuits, and introduction to data acquisition. Materials fee.

(Design units: 2)
Corequisite: MATH 3D
Prerequisite: PHYSICS 7D and PHYSICS 7LD
Overlaps with EECS 70A.
Restriction: Mechanical Engineering Majors have first consideration for enrollment. Aerospace Engineering Majors have first consideration for enrollment. Materials Science Engineering Majors have first consideration for enrollment.

ENGRMAE 80. Dynamics. 4 Units.
Introduction to the kinematics and dynamics of particles and rigid bodies. The Newton-Euler, Work/Energy, and Impulse/Momentum methods are explored for ascertaining the dynamics of particles and rigid bodies. An engineering design problem using these fundamental principles is also undertaken.

(Design units: 0.5)
Prerequisite: MATH 2D and PHYSICS 7C
Same as ENGRCEE 80, ENGR 80.
Restriction: Mechanical Engineering Majors have first consideration for enrollment. Aerospace Engineering Majors have first consideration for enrollment. Civil Engineering Majors have first consideration for enrollment. Materials Science Engineering Majors have first consideration for enrollment. Environmental Engineering Majors have first consideration for enrollment.

ENGRMAE 91. Introduction to Thermodynamics. 4 Units.
Thermodynamic principles; open and closed systems representative of engineering problems. First and second law of thermodynamics with applications to engineering systems and design.

(Design units: 0.5)
Prerequisite: PHYSICS 7C and MATH 2D
Overlaps with CBEMS 45B, CBEMS 65A.
Restriction: Mechanical Engineering Majors have first consideration for enrollment. Aerospace Engineering Majors have first consideration for enrollment. Civil Engineering Majors have first consideration for enrollment. Materials Science Engineering Majors have first consideration for enrollment. Environmental Engineering Majors have first consideration for enrollment.

ENGRMAE 93. Topics in Design Project . 1-2 Units.
Early-stage design/hands-on experience for lower-division students, and allows them to participate along side seniors in the design project.

(Design units: 1)
Repeatability: Unlimited as topics vary.
Restriction: Mechanical Engineering Majors have first consideration for enrollment. Aerospace Engineering Majors have first consideration for enrollment.

ENGRMAE 106. Mechanical Systems Laboratory. 4 Units.
Experiments in linear systems, including op-amp circuits, vibrations, and control systems. Emphasis on demonstrating that mathematical models can be useful tools for the analysis and design of electro-mechanical systems. Materials fee.

(Design units: 2)
Prerequisite: ENGRMAE 60 or EECS 70A
Restriction: Mechanical Engineering Majors have first consideration for enrollment. Aerospace Engineering Majors have first consideration for enrollment. Civil Engineering Majors have first consideration for enrollment. Materials Science Engineering Majors have first consideration for enrollment. Environmental Engineering Majors have first consideration for enrollment.
ENGRMAE 107. Fluid Thermal Science Laboratory. 4 Units.
Fluid and thermal engineering laboratory. Experimental analysis of fluid flow, heat transfer, and thermodynamic systems. Probability, statistics, and uncertainty analysis. Report writing is emphasized and a design project is required. Materials fee.

(Design units: 1)

Corequisite: ENGRMAE 120

Restriction: Mechanical Engineering Majors have first consideration for enrollment.

ENGRMAE 108. Aerospace Laboratory. 4 Units.
Analytical and experimental investigation in aerodynamics, fluid dynamics, and heat transfer. Emphasis on study of flow over objects and lift and drag on airfoils. Introduction to basic diagnostic techniques. Report writing is emphasized. Design project is required. Materials fee.

(Design units: 2)

Prerequisite: ENGRMAE 130B

Restriction: Aerospace Engineering Majors have first consideration for enrollment. Mechanical Engineering Majors have first consideration for enrollment.

ENGRMAE 110. Combustion and Fuel Cell Systems. 4 Units.
Fundamentals of gaseous, liquid, and coal-fired combustion and fuel cell systems. Fuels, fuel-air mixing, aerodynamics, and combustion and fuel cell thermodynamics. Operating and design aspects of practical systems including engines, power generators, boilers, furnaces, and incinerators.

(Design units: 2)

Prerequisite: ENGRMAE 115

Restriction: Mechanical Engineering Majors have first consideration for enrollment. Chemical Engineering Majors have first consideration for enrollment. Environmental Engineering Majors have first consideration for enrollment.

ENGRMAE 112. Propulsion. 4 Units.
Application of thermodynamics and fluid mechanics to basic flow processes and cycle performance in propulsion systems: gas turbines, ramjets, scramjets, and rockets.

(Design units: 1)

Prerequisite: ENGRMAE 135

Restriction: Mechanical Engineering Majors have first consideration for enrollment. Aerospace Engineering Majors have first consideration for enrollment.

ENGRMAE 113. Electric Propulsion. 4 Units.
Space propulsion requirements and maneuvers, stressing those best suited to electric propulsion. An introduction to plasma physics. Electrothermal, electromagnetic and electrostatic accelerators, with emphasis in technologies (ion engines, Hall thrusters and colloidal thrusters) belonging to the latter family.

(Design units: 1)

Prerequisite: ENGRMAE 112

Concurrent with ENGRMAE 213.

ENGRMAE 114. Fuel Cell Fundamentals and Technology. 4 Units.
Introduction to electrochemistry and electrocatalysis; nature of fuel-cell electrodes and electrolytes; charge transfer reactions at interfaces; charge transport and mass transport processes; fuel processing reactions; determination of fuel cell efficiency, fuel flexibility, emissions and other characteristics.

(Design units: 0)

Prerequisite: ENGRMAE 115

Restriction: Seniors only. Mechanical Engineering Majors have first consideration for enrollment. Aerospace Engineering Majors have first consideration for enrollment.

Concurrent with ENGRMAE 214A.
ENGRMAE 115. Applied Engineering Thermodynamics. 4 Units.
Application of thermodynamic principles to compressible and incompressible processes representative of practical engineering problems; power cycles, refrigeration cycles, multicomponent mixtures, air conditioning systems, combustion, and compressible flow. Design of a thermodynamic process.

(Design units: 2)
Prerequisite: ENGRMAE 91 or CBE 40B or ENGRMSE 65A
Restriction: Mechanical Engineering Majors have first consideration for enrollment. Materials Science Engineering Majors have first consideration for enrollment.

ENGRMAE 117. Solar and Renewable Energy Systems. 4 Units.
Basic principles, design, and operation of solar and other renewable energy systems including solar photo-voltaic, solar thermal, wind, and PEM fuel cell. Includes power generation and storage, and renewable fuels for transportation and stationary power generation.

(Design units: 1)
Prerequisite: ENGRMAE 91 or CBE 40B or ENGRMSE 65A
Restriction: Mechanical Engineering Majors have first consideration for enrollment.

ENGRMAE 118. Sustainable Energy Systems. 4 Units.
Basic principles, design, and operation of sustainable energy systems including wind, solar photo-voltaic and thermal, hydroelectric, geothermal, oceanic, biomass combustion, advanced coal, and next generation nuclear. Includes power generation, storage, and transmission for stationary power generation.

(Design units: 1)
Prerequisite: ENGRMAE 115
Concurrent with ENGRMAE 218.

ENGRMAE 120. Heat and Mass Transfer. 4 Units.
Fundamentals of heat and mass transfer. Conduction, heat and mass transfer by convection in laminar and turbulent flows, radiation heat transfer, and combined modes of heat and mass transfer. Practical engineering applications.

(Design units: 0)
Prerequisite: ENGRMAE 130B
Overlaps with CBEMS 125B.
Restriction: Aerospace Engineering Majors have first consideration for enrollment. Materials Science Engineering Majors have first consideration for enrollment.

ENGRMAE 130A. Introduction to Fluid Mechanics. 4 Units.
Fundamental concepts; fluid statics; fluid dynamics; Bernoulli’s equation; control-volume analysis; basic flow equations of conservation of mass, momentum, and energy; differential analysis; potential flow; viscous incompressible flow.

(Design units: 0)
Corequisite: ENGRMAE 91
Prerequisite: PHYSICS 7C and MATH 2D and MATH 2E and MATH 3D and (ENGRMAE 30 or ENGRCEE 30 or ENGR 30) and (ENGRMAE 80 or ENGRCEE 80 or ENGR 80). PHYSICS 7C with a grade of C- or better. MATH 2D with a grade of C- or better. MATH 2E with a grade of C- or better. MATH 3D with a grade of C- or better. MATH 3D with a grade of C- or better. ENGRMAE 30 with a grade of C- or better. ENGRCEE 30 with a grade of C- or better. ENGR 30 with a grade of C- or better. ENGRMAE 80 with a grade of C- or better. ENGRCEE 80 with a grade of C- or better. ENGR 80 with a grade of C- or better
Overlaps with CBEMS 125A, ENGRCEE 170.
Restriction: Mechanical Engineering Majors have first consideration for enrollment. Aerospace Engineering Majors have first consideration for enrollment.
ENGRMAE 130B. Introduction to Viscous and Compressible Flows. 4 Units.
Introduction to the analysis of viscous flows including fully developed laminar and turbulent flow in a pipe, viscous flow over immersed bodies, evaluation of boundary layer characteristics, lift and drag, compressible flow in a duct and normal shock waves.

(Design units: 1)
Prerequisite: ENGRMAE 130A
Restriction: Mechanical Engineering Majors have first consideration for enrollment. Aerospace Engineering Majors have first consideration for enrollment.

ENGRMAE 132. Computational Fluid Dynamics. 4 Units.
Introduction to computational fluid dynamics in simple engineering devices. The numerical simulations will be performed via the widely-used software ANSYS-Fluent. While Fluent is the choice of software, all major CFD packages are based on a similar numerical method.

(Design units: 0)
Prerequisite: ENGRMAE 130B. ENGRMAE 130B with a grade of C- or better
Restriction: Aerospace Engineering Majors only. Mechanical Engineering Majors only.

ENGRMAE 135. Compressible Flow. 4 Units.
Compressibility effects in fluid mechanics. One-dimensional flow with area variation, friction, heat transfer, and shocks. Design of gas supply systems. Two-dimensional flow with oblique shocks and isentropic waves. Supersonic airfoil theory and design, wind tunnel design. Basic diagnostics.

(Design units: 1)
Prerequisite: ENGRMAE 130A
Restriction: Mechanical Engineering Majors have first consideration for enrollment. Aerospace Engineering Majors have first consideration for enrollment.

ENGRMAE 136. Aerodynamics. 4 Units.
Analysis of flow over aircraft wings and airfoils, prediction of lift, moment, and drag. Topics: fluid dynamics equations; flow similitude; viscous effects; vorticity, circulation, Kelvin's theorem, potential flow; superposition principle, Kutta-Joukowski theorem; thin airfoil theory; finite wing theory; compressibility.

(Design units: 1)
Prerequisite: ENGRMAE 130B
Restriction: Aerospace Engineering Majors have first consideration for enrollment. Mechanical Engineering Majors have first consideration for enrollment.

ENGRMAE 145. Theory of Machines and Mechanisms. 4 Units.
Presents the basic mathematical theory of machines. Focuses on the principles of cam design, gearing and gear train analysis, and the kinematic and dynamic analysis of linkages, together with an introduction to robotics.

(Design units: 2)
Prerequisite: ENGRMAE 52 and ENGRMAE 80 and MATH 3A
Restriction: Mechanical Engineering Majors have first consideration for enrollment. Materials Science Engineering Majors have first consideration for enrollment.

ENGRMAE 146. Astronautics. 4 Units.
Motion in gravitational force fields, orbit transfers, rocketry, interplanetary trajectories, attitude dynamics and stabilization, navigation, reentry, the space environment.

(Design units: 1)
Prerequisite: ENGRMAE 80
Restriction: Aerospace Engineering Majors have first consideration for enrollment.
ENGRMAE 147. Vibrations. 4 Units.
Analysis of structural vibrations of mechanical systems. Modeling for lumped and distributed parameter systems. Topics include single and multi-degree of freedom systems, free and forced vibrations, Fourier series, convolution integral, mass/stiffness matrices, and normal modes with design project.
(Design units: 1)
Prerequisite: (ENGR 80 or ENGRCEE 80 or ENGRMAE 80) and MATH 2E and MATH 3D
Restriction: Mechanical Engineering Majors have first consideration for enrollment. Materials Science Engineering Majors have first consideration for enrollment.

ENGRMAE 150. Mechanics of Structures. 4 Units.
(Design units: 2)
Prerequisite: (ENGRCEE 30 or ENGR 30 or ENGRMAE 30) and MATH 3A
Same as ENGR 150.
Overlaps with ENGRCEE 150.
Restriction: Mechanical Engineering Majors have first consideration for enrollment. Aerospace Engineering Majors have first consideration for enrollment. Chemical Engineering Majors have first consideration for enrollment. Materials Science Engineering Majors have first consideration for enrollment.

ENGRMAE 150L. Mechanics of Structures Laboratory. 1 Unit.
(Design units: 0)
Corequisite: ENGRMAE 150
Prerequisite: ENGRMAE 30 or ENGR 30 or ENGRCEE 30
Overlaps with ENGRCEE 150L.
Restriction: Mechanical Engineering Majors have first consideration for enrollment. Aerospace Engineering Majors have first consideration for enrollment. Materials Science Engineering Majors have first consideration for enrollment.

ENGRMAE 151. Mechanical Engineering Design. 4 Units.
A comprehensive group design project experience that involves identifying customer needs, idea generation, reverse engineering, preliminary design, standards, prototype development, testing, analysis, and redesign of a product involving fluid, thermal, and mechanical components. Introduces design for manufacturing and the environment. Materials fee.
(Design units: 3)
Corequisite: ENGRMAE 170
Prerequisite: ENGRMAE 120 and ENGRMAE 145
Restriction: Seniors only. Mechanical Engineering Majors have first consideration for enrollment. Materials Science Engineering Majors have first consideration for enrollment.

ENGRMAE 152. Introduction to Computer-Aided Engineering. 4 Units.
Elements and principles of computer-aided engineering with modern hardware and software are presented with a design focus. Case studies are used to assist in finite-element method techniques. Not offered every year.
(Design units: 2)
Prerequisite: (ENGRMAE 150 or ENGR 150) and ENGRMAE 120
Restriction: Materials Science Engineering Majors have first consideration for enrollment.
ENGRMAE 153. Advanced BIOMEMS Manufacturing Techniques. 4 Units.
Introduction to BIOMEMS. Advanced biotechnology/biomedicine equipment based on MEMS and NEMS. Fundamentals of MEMS/NEMS sensing techniques and the biological and physics principles involved and the preferred MEMS and NEMS manufacturing techniques.

(Design units: 0)
Concurrent with ENGRMAE 253.

ENGRMAE 155. Composite Materials and Structures. 4 Units.
Motivation for composite materials. Different classifications according to the nature of the matrix (PMC, MMC, CMC) and the reinforcement topology (fibers, whiskers, particulates). Mechanical properties. Failure mechanisms. Designing with composite materials. Advantages and limitations of homogenization techniques for numerical modeling.

(Design units: 0)
Prerequisite: ENGR 54 and (ENGRMAE 150 or ENGRCEE 150 or ENGR 150)
Restriction: Chemical Engineering Majors have first consideration for enrollment. Civil Engineering Majors have first consideration for enrollment. Materials Science Engineering Majors have first consideration for enrollment. Mechanical Engineering Majors have first consideration for enrollment.
Concurrent with ENGRMAE 255.

ENGRMAE 156. Mechanical Behavior and Design Principles. 4 Units.
Principles governing structure and mechanical behavior of materials, relationship relating microstructure and mechanical response with application to elasticity, plasticity, yielding, necking, creep, and fracture of materials. Introduction to experimental techniques to characterize the properties of materials. Design parameters.

(Design units: 2)
Prerequisite: ENGR 54
Same as ENGRMSE 155.
Restriction: Mechanical Engineering Majors have first consideration for enrollment. Chemical Engineering Majors have first consideration for enrollment. Materials Science Engineering Majors have first consideration for enrollment.

ENGRMAE 157. Lightweight Structures. 4 Units.

(Design units: 2)
Prerequisite: ENGR 150 or ENGRCEE 150 or ENGRMAE 150
Restriction: Aerospace Engineering Majors only. Civil Engineering Majors only. Materials Science Engineering Majors only. Mechanical Engineering Majors only.

ENGRMAE 158. Aircraft Performance. 4 Units.
Flight theory applied to subsonic propeller and jet aircraft. Nature of aerodynamic forces, drag and lift of wing and fuselage, high-lift devices, level-flight performance, climb and glide performance, range, endurance, take-off and landing distances, static and dynamic stability and control.

(Design units: 2)
Prerequisite: ENGRMAE 130A or ENGRCEE 170 or CBE 120A
Restriction: Mechanical Engineering Majors have first consideration for enrollment. Aerospace Engineering Majors have first consideration for enrollment.

ENGRMAE 159. Aircraft Design. 4 Units.
Preliminary design of subsonic general aviation and transport aircraft with emphasis on layout, aerodynamic design, propulsion, and performance. Estimation of total weight and weight distribution, design of wings, fuselage, and tail, selection and location of engines, prediction of overall performance.

(Design units: 4)
Prerequisite: ENGRMAE 112 and ENGRMAE 136 and ENGRMAE 158
Restriction: Aerospace Engineering Majors have first consideration for enrollment. Mechanical Engineering Majors have first consideration for enrollment.
ENGRMAE 164. Air Pollution and Control. 4 Units.
Sources, dispersion, and effects of air pollutants. Topics include emission factors, emission inventory, air pollution, meteorology, air chemistry, air quality modeling, impact assessment, source and ambient monitoring, regional control strategies.

(Design units: 2)
Prerequisite: (ENGRMAE 91 or CBE 40B or ENGRMSE 65A) and (ENGRMAE 130A or ENGRCEE 170 or CBE 120A)
Restriction: Mechanical Engineering Majors have first consideration for enrollment. Chemical Engineering Majors have first consideration for enrollment. Environmental Engineering Majors have first consideration for enrollment.

ENGRMAE 170. Introduction to Control Systems. 4 Units.

(Design units: 2)
Prerequisite: (ENGRMAE 80 or ENGRCEE 80 or ENGR 80) and ENGRMAE 106
Restriction: Mechanical Engineering Majors have first consideration for enrollment. Aerospace Engineering Majors have first consideration for enrollment. Civil Engineering Majors have first consideration for enrollment. Materials Science Engineering Majors have first consideration for enrollment.

ENGRMAE 171. Digital Control Systems. 4 Units.

(Design units: 2)
Prerequisite: ENGRMAE 170
Restriction: Civil Engineering Majors have first consideration for enrollment. Mechanical Engineering Majors have first consideration for enrollment.

ENGRMAE 172. Design of Computer-Controlled Robots. 4 Units.
Students design a small robotic device and program it to exhibit sentient behaviors. The basic aspects of mechatronic design are covered, including motor and sensor selection, control strategies, and microcomputer programming for the implementation of control paradigms.

(Design units: 3)
Corequisite: ENGRMAE 60
Prerequisite: ENGRMAE 170
Restriction: Mechanical Engineering Majors have first consideration for enrollment.
Concurrent with ENGRMAE 280.

ENGRMAE 175. Dynamics and Control of Aerospace Vehicles. 4 Units.

(Design units: 3)
Prerequisite: ENGRMAE 106
Restriction: Aerospace Engineering Majors have first consideration for enrollment. Mechanical Engineering Majors have first consideration for enrollment.

ENGRMAE 183. Computer-Aided Mechanism Design. 4 Units.
Focuses on design of planar, spherical, and spatial mechanisms using computer algebra and graphics. Topics include exact and approximate analytical design techniques. Students are required to use existing software (or develop new algorithms) to design various mechanisms for new applications.

(Design units: 4)
Prerequisite: MATH 3A or I&C SCI 6N
Restriction: Mechanical Engineering Majors have first consideration for enrollment.
ENGRMAE 184. Fundamentals of Experimental Design. 4 Units.
Review of statistics as applied to experimental research. Fundamentals and principles of statistical experimental design and analysis with emphasis on understanding and use of designed experiments, response surfaces, linear regression modeling, and process optimization.

(Design units: 1)
Restriction: Mechanical Engineering Majors have first consideration for enrollment. Aerospace Engineering Majors have first consideration for enrollment.
Concurrent with ENGRMAE 284.

ENGRMAE 185. Numerical Analysis in Mechanical Engineering. 4 Units.

(Design units: 2)
Prerequisite: (ENGRMAE 10 or EECS 10 or EECS 12 or BME 60B) and MATH 3D and MATH 2E
Overlaps with MATH 105A.

ENGRMAE 188. Engineering Design in Industry. 4 Units.
Principles of engineering design in the context of an industrial application. Local manufacturing firms define an engineering design project to be completed in 10 weeks. Projects include initial brainstorming to final design, with a formal presentation.

(Design units: 4)
Repeatability: May be taken for credit 3 times.
Restriction: Mechanical Engineering Majors have first consideration for enrollment.

ENGRMAE 189. Senior Project - Special Topics. 1-4 Units.
Group or individual senior project of theoretical or applied nature involving design. Materials fee.

(Design units: 1-4)
Repeatability: May be taken for credit for 12 units as topics vary.
Restriction: Seniors only. Mechanical Engineering Majors only.

ENGRMAE 193. Topics in MAE Design. 1-4 Units.
Provides early-stage design/hands-on experience for upper-division students, and allows them to participate in senior design projects course ENGRMAE 189.

(Design units: 1)
Repeatability: May be taken for credit for 12 units as topics vary.
Restriction: Aerospace Engineering Majors have first consideration for enrollment. Mechanical Engineering Majors have first consideration for enrollment.

ENGRMAE 195. Seminars in Engineering. 1-4 Units.
Seminars by individual faculty in major fields of interest. Materials fee.

(Design units: 1-4)
Repeatability: Unlimited as topics vary.

ENGRMAE 198. Group Study. 1-4 Units.
Group study of selected topics in Aerospace and Mechanical Engineering.

(Design units: 1-4)
Repeatability: May be repeated for credit unlimited times.
Restriction: Upper-division students only.
ENGRMAE 199. Individual Study. 1-4 Units.
For undergraduate Engineering majors in supervised but independent reading, research, or design. Students taking individual study for design credit are to submit a written paper to the instructor and to the Undergraduate Student Affairs Office in the School of Engineering.

(Design units: 1-4)
Repeatability: May be taken for credit for 8 units.

ENGRMAE 199P. Individual Study. 1-4 Units.
For undergraduate Engineering majors in supervised but independent reading, research, or design. Students taking individual study for design are to submit a written paper to the instructor and to the Undergraduate Student Affairs Office in the School of Engineering.

(Design units: 1-4)
Grading Option: Pass/no pass only.
Repeatability: May be repeated for credit unlimited times.

ENGRMAE 200A. Engineering Analysis I. 4 Units.
Linear algebra, including vector spaces, matrices, linear systems of equations, least squares, and the eigenvalue problem. Ordinary differential equations, including analytical and numerical solution methods, stability, and phase portraits.
Restriction: Graduate students only.

ENGRMAE 200B. Engineering Analysis II. 4 Units.
Review of ordinary differential equations, including Bessel and Legendre functions. Partial differential equations, including the diffusion equation, Laplace's equation, and the wave equation. Fourier series, Fourier and Laplace transforms and their applications.
Restriction: Graduate students only.

ENGRMAE 205. Perturbation Methods in Engineering. 4 Units.
Prerequisite: ENGRMAE 200A and ENGRMAE 200B. Knowledge of linear differential equations.
Restriction: Graduate students only.

ENGRMAE 206. Nonlinear Optimization Methods. 4 Units.
Prerequisite: ENGRMAE 200A
Restriction: Graduate students only.

ENGRMAE 207. Methods of Computer Modeling in Engineering and the Sciences. 4 Units.
Unified introduction to finite volume, finite element, field-boundary element, meshless, primal, dual, and mixed methods. Nonlinear problems posed by ordinary as well as partial differential equations. Computer implementations and comparisons of accuracy and convergence.
Restriction: Graduate students only.

ENGRMAE 210. Advanced Fundamentals of Combustion. 4 Units.
Premixed, nonpremixed, and heterogenous reactions, with emphasis on kinetics, thermal ignition, turbulent flame propogation, detonations, explosions, flammability limits, diffusion flame, quenching, flame stabilization, and particle and spray combustion. Not offered every year.
Prerequisite: ENGRMAE 224 or ENGRMAE 230B
Restriction: Graduate students only.

ENGRMAE 212. Engineering Electrochemistry: Fundamentals and Applications. 4 Units.
Introduction to engineering electrochemistry fundamentals and applications. Examine thermodynamics and transport principles in typical electrochemical systems. Electrochemical sensors, batteries, fuel cells, and supercapacitors. Manufacturing aspects will also be covered.
Restriction: Graduate students only.
ENGRMAE 213. Electric Propulsion. 4 Units.
Space propulsion requirements and maneuvers, stressing those best suited to electric propulsion. An introduction to plasma physics. Electrothermal, electromagnetic and electrostatic accelerators, with emphasis in technologies (ion engines, Hall thrusters and colloidal thrusters) belonging to the latter family.

Restriction: Graduate students only.
Concurrent with ENGRMAE 113.

ENGRMAE 214A. Fuel Cell Fundamentals and Technology. 4 Units.
Introduction to electrochemistry and electrocatalysis; nature of fuel-cell electrodes and electrolytes; charge transfer reactions at interfaces; charge transport and mass transport processes; fuel processing reactions; determination of fuel cell efficiency, fuel flexibility, emissions and other characteristics.

Restriction: Graduate students only.
Concurrent with ENGRMAE 114.

ENGRMAE 214B. Fuel Cell Systems and Degradation. 4 Units.
Fuel cell systems design; impacts of operating conditions; experimental and theoretical analysis methods for fuel cells systems; introduction to degradation mechanisms and mitigation techniques; provides broad insight into fuel-cell science, technology, system design and operation. Offered every other year.

Prerequisite: ENGRMAE 214A
Restriction: Graduate students only.

ENGRMAE 214C. PEM Fuel Cells. 4 Units.
An in-depth introduction to the fundamentals of PEM fuel cells, including thermodynamics, kinetics, and transport in electrochemical systems. Topics of specific interest to mechanical engineers will include water/heat management and dynamic responses.

Prerequisite: ENGRMAE 214A
Restriction: Graduate students only.

ENGRMAE 215. Advanced Combustion Technology. 4 Units.
Pollutant formation and experimental methods. Formation of gaseous pollutants and soot; transformation and emission of fuel contaminants in gas, liquid, and solid fuel combustion; methods employed to measure velocity, turbulence intensity, temperature, composition, particle size; methods to visualize reacting flows.

Prerequisite: ENGRMAE 200A and (ENGRMAE 230A or ENGRMAE 270A)
Restriction: Graduate students only.

ENGRMAE 216. Statistical Thermodynamics. 4 Units.
Statistics of independent particles, development of quantum mechanical description of atoms and molecules, application of quantum mechanics, evaluation of thermodynamics properties for solids, liquids, and gases, statistical mechanics of dependent particles (ensembles).

Restriction: Graduate students only.

ENGRMAE 217. Generalized Thermodynamics. 4 Units.
Generalized thermodynamics develops the laws of continuum thermodynamics from a set of plausible and intuitive postulates. The postulates are motivated qualitatively by a statistical description of matter and are justified by a posterior success for the resulting theory.

Restriction: Graduate students only.

ENGRMAE 218. Sustainable Energy Systems. 4 Units.
Basic principles, design and operation of sustainable energy systems including wind, solar photo-voltaic and thermal, hydroelectric, geothermal, oceanic, biomass combustion, advanced coal and next generation nuclear. Includes power generation, storage, and transmission for stationary power generation.

Restriction: Graduate students only.
Concurrent with ENGRMAE 118.
ENGRMAE 220. Conduction Heat Transfer. 4 Units.
Steady state and transient conduction heat transfer in one- and multi-dimensional geometries. Analytical methods, exact and approximate. Numerical techniques are also included.
Restriction: Graduate students only.

ENGRMAE 221. Convective Heat and Mass Transfer. 4 Units.
Prerequisite: ENGRMAE 230B
Restriction: Graduate students only.

ENGRMAE 222. Radiative Heat Transfer. 4 Units.
Restriction: Graduate students only.

ENGRMAE 223A. Numerical Methods in Heat, Mass, and Momentum Transport (Laminar Flows) I. 4 Units.
Introduction to the discretization of various types of partial differential equations (parabolic, elliptic, hyperbolic). Finite-volume discretization for one- and two-dimensional flows. Use of a two-dimensional elliptic procedure to predict sample laminar flows.
Prerequisite or corequisite: ENGRMAE 230A
Restriction: Graduate students only.

ENGRMAE 223B. Numerical Methods in Heat, Mass, and Momentum II. 4 Units.
Prerequisite: ENGRMAE 223A
Restriction: Graduate students only.

ENGRMAE 224. Advanced Transport Phenomena. 4 Units.
Restriction: Graduate students only.

ENGRMAE 226. Special Topics in Fluid and Thermal Sciences. 1-4 Units.
Special topics of current interest in fluid mechanics, heat and mass transfer, multiphase flows, or combustion. Emphasis could be placed on theory, computational methods, or experimental techniques.
Repeatability: Unlimited as topics vary.
Restriction: Graduate students only.

ENGRMAE 227. Thermal Resistance Analysis in Microdevices and Nanomaterials. 4 Units.
Heat transfer and thermal resistance analysis relevant for microdevices and nanomaterials. Overview of recent progress in nanotechnology and materials science. Thermal modeling strategies for novel electronic devices and energy conversion systems.
Restriction: Graduate students only.

ENGRMAE 228. Nanoscale Phase Change Transport Physics. 4 Units.
Discusses a wide range of phase change processes (i.e., evaporation, boiling, condensation, and freezing) through the use of novel thermal metamaterials with the aim of enhancing phase change performances.
Prerequisite: Undergraduate-level heat transfer is recommended.
Restriction: Graduate students only.
ENGRMAE 230A. Inviscid Incompressible Fluid Mechanics I. 4 Units.
Restriction: Graduate students only.

ENGRMAE 230B. Viscous Incompressible Fluid Mechanics II. 4 Units.
Restriction: Graduate students only.

ENGRMAE 230C. Compressible Fluid Dynamics. 4 Units.
Prerequisite: ENGRMAE 230A or ENGRMAE 230B
Restriction: Graduate students only.

ENGRMAE 230D. Theoretical Foundations of Fluid Mechanics. 4 Units.
Prerequisite: ENGRMAE 230A and ENGRMAE 230B
Restriction: Graduate students only.

ENGRMAE 231. Fundamentals of Turbulence. 4 Units.
Prerequisite: ENGRMAE 230A and ENGRMAE 230B
Restriction: Graduate students only.

ENGRMAE 233. Turbulent Free Shear Flows. 4 Units.
Prerequisite: ENGRMAE 200B and ENGRMAE 230A and ENGRMAE 230B
Restriction: Graduate students only.

ENGRMAE 236. Nonequilibrium Gas Dynamics. 4 Units.
Prerequisite: ENGRMAE 230C
Restriction: Graduate students only.

ENGRMAE 237. Computational Fluid Dynamics. 4 Units.
Mathematical, physical, and computational fundamentals of computational fluid dynamics, numerical methods for solving the Euler and Navier-Stokes equations. Topics include: finite-difference and finite-volume discretization, time marching methods, von Neumann analysis, upwinding, flux splitting, TVD, and other high-resolution shock-capturing schemes.
Prerequisite: ENGRMAE 230C
Restriction: Graduate students only.
ENGRAE 238. Experimental Fluid Dynamics. 4 Units.
Prerequisite: ENGRMAE 230A and ENGRMAE 230B
Restriction: Graduate students only.

ENGRAE 239. Dynamics of Unsteady Flows. 4 Units.
Prerequisite: ENGRMAE 230A is recommended.
Restriction: Graduate students only.

ENGRAE 241. Dynamics. 4 Units.
Kinematics and dynamics of three-dimensional motions. Lagrange's equations, Newton-Euler equations. Applications include robot systems and spinning satellites.
Restriction: Graduate students only.

ENGRAE 242. Robotics. 4 Units.
Restriction: Graduate students only.

ENGRAE 244. Theoretical Kinematics. 4 Units.
Spatial rigid body kinematics is presented with applications to robotics. Orthogonal Matrices, Rodrigues' formula, Quaternions, Plucker coordinates, screw theory, and dual numbers are studied using modern projective geometry and multi-linear algebra. Applications include trajectory planning, inverse kinematics, and workspace analysis.
Restriction: Graduate students only.

ENGRAE 245. Spatial Mechanism Design. 4 Units.
Fundamental kinematic theory required for planar, spherical, and spatial mechanism design. The focus is on algebraic methods for the exact solution of constraint equations. Not offered every year.
Restriction: Graduate students only.

ENGRAE 247. Micro-System Design. 4 Units.
Covers the fundamentals of the many disciplines needed for design of Micro-Electro-Mechanical Systems (MEMS): microfabrication technology, structural mechanics on micro-scale, electrostatics, circuit interface, control, computer-aided design, and system integration.
Same as EECS 278.
Restriction: Graduate students only.

ENGRAE 249. Micro-Sensors and Actuators. 4 Units.
Introduction to the technology of Micro-Electro-Mechanical Systems (MEMS). Fundamental principles and applications of important microsensors, actuation principles on microscale. Introduction to the elements of signal processing; processing of materials for micro sensor/actuator fabrication; smart sensors and microsensor/microactuator array devices.
Same as EECS 279.
Restriction: Graduate students only.

ENGRAE 250. Biorobotics. 4 Units.
Sensors, actuators, and neural circuits for biological movement control from an engineering perspective. Current approaches to robotic and mechatronic devices that support and enhance human movement in health and following neurologic injuries like stroke and spinal cord injury.
Restriction: Graduate students only.
ENGRMAE 252. Fundamentals of Microfabrication. 4 Units.
Introduces Engineering and Science students to the science of miniaturization. Different options to make very small machines (micro and nano size) are reviewed, materials choices are discussed, scaling laws are analyzed, and many practical applications are listed.

Restriction: Graduate students only.

ENGRMAE 253. Advanced BIOMEMS Manufacturing Techniques. 4 Units.
Introduction to BIOMEMS. Advanced biotechnology/biomedicine equipment based on MEMS and NEMS. Fundamentals of MEMS/NEMS sensing techniques and the biological and physics principles involved and the preferred MEMS and NEMS manufacturing techniques.

Restriction: Graduate students only.

ENGRMAE 254. Mechanics of Solids and Structures. 4 Units.
Finite deformation kinematics; stress and strain measures; invariance in solid mechanics; objective rates; constitutive theory of elastic and inelastic solids; rate formulations; computational approaches; theories of plates and shells; applications to aerospace vehicles.

Restriction: Graduate students only.

ENGRMAE 255. Composite Materials and Structures. 4 Units.
Motivation for composite materials. Different classifications according to the nature of the matrix (PMC, MMC, CMC) and the reinforcement topology (fibers, whiskers, particulates). Mechanical properties. Failure mechanisms. Designing with composite materials. Advantages and limitations of homogenization techniques for numerical modeling.

Restriction: Graduate students only.

ENGRMAE 256. Nanomechanics. 4 Units.
Nanoscale materials and the experimental and computational techniques used to measure their properties. Mechanical behavior is the main focus, but other material properties such as diffusion and electron transport are discussed.

Restriction: Graduate students only.

ENGRMAE 258. Mechanical Behavior of Solids - Continuum Theories. 4 Units.
Presents a continuum, macroscopic view of deformation and failure of solids. Covers elasticity, plasticity, visco-elasticity, visco-plasticity, fracture and fatigue. Topics include discussions of physical behavior, mathematical formalism and measurement techniques.

Prerequisite: ENGRMAE 254

Restriction: Graduate students only.

ENGRMAE 259. Mechanical Behavior of Solids - Atomistic Theories. 4 Units.
Presents atomistic mechanisms that control mechanical behavior of materials. Covers plasticity, dislocation theory, strengthening mechanisms, high-temperature diffusion and gain boundary sliding, shear localization, void formation, ductile rupture, brittle fracture and fatigue.

Restriction: Graduate students only.

ENGRMAE 260. Current Issues Related to Air Quality, Climate, and Energy. 4 Units.
Current issues related to the atmosphere, climate, and air quality in the context of energy conversion and sustainability. Topics include transportation systems; building design; impacts on humans and ecosystems; modeling and meteorology; economics; and application to public policies.

Prerequisite: ENGRMAE 261 or CHEM 245 or EARTHSS 240

Same as CHEM 241.

Restriction: Graduate students only.

ENGRMAE 270A. Linear Systems I. 4 Units.
Input-output and state-space representations of continuous-time linear systems. State transition matrices, Controllability and observability. Irreducible realizations. State feedback and observer design.

Restriction: Graduate students only.
ENGRMAE 270B. Linear Systems II. 4 Units.

Prerequisite: ENGRMAE 270A
Restriction: Graduate students only.

ENGRMAE 272. Robust Control Theory. 4 Units.

Prerequisite: ENGRMAE 270A
Restriction: Graduate students only.

ENGRMAE 274. Optimal Control. 4 Units.
Principles and methods of optimal control. Topics include objectives and issues in controlling nonlinear systems; linear variational and adjoint equations; optimality conditions via variational calculus, maximum principle, and dynamic programming; solution methods; applications to control robots and aerospace vehicles.

Prerequisite: ENGRMAE 200A and ENGRMAE 270A
Restriction: Graduate students only.

ENGRMAE 275. Nonlinear Feedback Systems. 4 Units.
Advanced tools for feedback control system analysis and synthesis. Norms, operators, Lp spaces, contraction mapping theorem, Lyapunov techniques along with their extensions. Circle criterion positivity and passivity. Applications to nonlinear control methods, such as sliding mode or adaptive techniques.

Prerequisite: ENGRMAE 270B
Restriction: Graduate students only.

ENGRMAE 276. Geometric Nonlinear Control. 4 Units.
Using the mathematics of differential geometry, a number of the concepts and results of linear systems theory have been extended to nonlinear systems. Describes these extensions and illustrate their use in nonlinear system analysis and design. Not offered every year.

Prerequisite: ENGRMAE 200A and ENGRMAE 270A
Restriction: Graduate students only.

ENGRMAE 277. Learning Control Systems. 4 Units.

Restriction: Graduate students only.

ENGRMAE 278. Parameter and State Estimation. 4 Units.

Prerequisite: ENGRMAE 200A and ENGRMAE 270A
Restriction: Graduate students only.

ENGRMAE 279. Special Topics in Mechanical Systems. 4 Units.
Selected topics of current interest in mechanical systems. Topics include robotics, kinematics, control, dynamics, and geometric modeling.

Prerequisite: ENGRMAE 270A and ENGRMAE 241
Repeatability: Unlimited as topics vary.
Restriction: Graduate students only.
ENGRMAE 280. Design of Computer-Controlled Robots. 4 Units.
The basic aspects of mechatronic design are covered, including motor and sensor selection, control strategies, finite state machines, inertial measurement units, and implementation of advanced feedback control laws. Students work in groups to create their own mechatronic device.

Restriction: Graduate students only.

Concurrent with ENGRMAE 172.

ENGRMAE 284. Fundamentals of Experimental Design. 4 Units.
Fundamentals and principles of statistical experimental design and analysis. Emphasis addresses understanding and use of designed experiments, response surfaces, linear regression modeling, process optimization, and development of links between empirical and theoretical models.

Restriction: Graduate students only.

Concurrent with ENGRMAE 184.

ENGRMAE 294. Master of Science Thesis Project. 4 Units.
Tutorial in which masters-level students taking the comprehensive examination option undertake a masters-level research project.

Repeatability: May be repeated for credit unlimited times.

Restriction: Graduate students only.

ENGRMAE 295. Special Topics in Mechanical and Aerospace Engineering. 1-4 Units.
Special topics by individual faculty in major fields of interest.

Repeatability: Unlimited as topics vary.

ENGRMAE 296. Master of Science Thesis Research. 1-16 Units.
Individual research or investigation conducted in the pursuit of preparing and completing the thesis required for the M.S. in Engineering.

Repeatability: May be repeated for credit unlimited times.

ENGRMAE 297. Doctor of Philosophy Dissertation Research. 1-16 Units.
Individual research or investigation conducted in the pursuit of preparing and completing the dissertation required for the Ph.D. in Engineering.

Repeatability: May be repeated for credit unlimited times.

ENGRMAE 298. Seminars in Mechanical and Aerospace Engineering. 1 Unit.
Presentation of advanced topics and reports of current research efforts in mechanical engineering. Required of all graduate students in mechanical engineering.

Grading Option: Satisfactory/unsatisfactory only.

Repeatability: May be repeated for credit unlimited times.

ENGRMAE 299. Individual Research. 1-16 Units.
Individual research or investigation under the direction of an individual faculty member.

Repeatability: May be repeated for credit unlimited times.

Restriction: Consent of instructor to enroll