The Henry Samueli School of Engineering

Gregory Washington, Dean
5200 Engineering Hall
Undergraduate Counseling: 949-824-4334
Graduate Counseling: 949-824-8090
http://www.eng.uci.edu/

Overview

The academic mission of The Henry Samueli School of Engineering has been developed to be consistent with the missions and goals set for it by the State of California, the University of California, and the University of California, Irvine (UCI) campus. Specifically, the academic mission of the School is to educate students, at all levels, to be the best engineers and leaders in the nation and world by engaging them in a stimulating community dedicated to the discovery of knowledge, creation of new technologies, and service to society.

The individual engineering and related programs have published program objectives that are consistent with the missions and goals of the University of California, UCI, and The Henry Samueli School of Engineering.

The School offers undergraduate majors in Aerospace Engineering (AE), Biomedical Engineering (BME), Biomedical Engineering: Premedical (BMEP), Chemical Engineering (ChE), Civil Engineering (CE), Computer Engineering (CpE), Computer Science and Engineering (CSE, a jointly administered program with the Donald Bren School of Information and Computer Sciences), Electrical Engineering (EE), Engineering (a general program, GE), Environmental Engineering (EnE), Materials Science Engineering (MSE), and Mechanical Engineering (ME). The undergraduate majors in Aerospace, Biomedical, Chemical, Civil, Computer, Computer Science and Engineering, Electrical, Environmental, Materials Science, and Mechanical Engineering are accredited by the Engineering Accreditation Commission of ABET (http://www.abet.org). Computer Science and Engineering (CSE) is also accredited by the Computing Accreditation Commission of ABET (http://www.abet.org). The undergraduate major in Biomedical Engineering: Premedical (BMEP) is not designed to be accredited, therefore is not accredited by ABET.

Aerospace Engineering considers the flight characteristics, performance, and design of aircraft and spacecraft. An upper-division series of courses in aerodynamics, propulsion, structures, and control follows a common core with Mechanical Engineering. The skills acquired in those courses are integrated in the capstone aerospace design course. The intent of the program is to produce highly proficient engineers who can tackle the aerospace engineering challenges of the future.

Biomedical Engineering applies engineering principles to solve complex medical problems and focuses at improving the quality of health care by advancing technology and reducing costs. Examples include advanced biomedical imaging systems, the design of microscale diagnostic systems, drug delivery systems, and tissue engineering. Specializations are available that focus student’s technical expertise on biophotonics or biomems.

Biomedical Engineering: Premedical shares introductory engineering courses with Biomedical Engineering, but replaces senior engineering laboratories and design courses with biology and organic chemistry courses required by medical schools for admission. The intent of the program is to produce students with a basic engineering background who are qualified to enter medical school.

Chemical Engineering applies the knowledge of chemistry, mathematics, physics, biology, and humanities to solve societal problems in areas such as energy, health, the environment, food, textiles, shelter, semiconductors, and homeland security. Employment opportunities exist in various industries such as chemical, petroleum, polymer, pharmaceutical, food, textile, fuel, consumer products, and semiconductor, as well as in local, state, and federal governments.

Civil Engineering addresses the challenges of large-scale engineering projects of importance to society as a whole, such as water distribution, transportation, and building design. Specializations are provided in General Civil Engineering, Environmental Hydrology and Water Resources, Structural Engineering, and Transportation Systems Engineering.

Computer Engineering addresses the design and analysis of digital computers, including both software and hardware. Computer design includes topics such as computer architecture, VLSI circuits, data base, software engineering, design automation, system software, and data structures and algorithms. Courses include programming in high-level languages such as Python, Java, C, C++; use of software packages for analysis and design; design of system software such as operating systems and hardware/software interfaces; application of computers in solving engineering problems, and laboratories in both hardware and software experiences.

Computer Science and Engineering is designed to provide students with the fundamentals of computer science, both hardware and software, and the application of engineering concepts, techniques, and methods to both computer systems engineering and software system design. The program gives students access to multidisciplinary problems in engineering with a focus on total systems engineering. Students learn the computer science principles that are critical to development of software, hardware, and networking of computer systems. From that background, engineering concepts and methods are added to give students exposure to circuit design, network design, and digital signal processing. Elements of engineering practice include systems view, manufacturing and economic issues, and multidisciplinary engineering applications. The program is administered jointly by the Department of Electrical Engineering and Computer Science in The Henry Samueli School of Engineering and by the Department of Computer Science in the Donald Bren School of Information and Computer Sciences.
Electrical Engineering is one of the major contributors to the modernization of our society. Many of the most basic and pervasive products and services are either based on or related to the scientific and engineering principles taught at the Department of Electrical Engineering and Computer Science. Students specialize in Electronic Circuit Design; Semiconductors and Optoelectronics; RF, Antennas and Microwaves; Digital Signal Processing; or Communications.

The major in Engineering is a special program of study for upper-division students who wish to combine the study of engineering principles with other areas such as the physical and biological sciences, social and behavioral science, humanities, and arts. Students may construct their own specialization. Click on the "Undergraduate Study" tab above for information about this major.

Environmental Engineering concerns the development of strategies to control and remediate polluted natural systems. Emphasis areas include air quality and combustion, water quality, and water resources engineering.

Materials Science Engineering is concerned with the generation and application of knowledge relating the composition, structure, and synthesis of materials to their properties and applications. During the past two decades, Materials Science Engineering has become an indispensable component of modern engineering education, partly because of the crucial role materials play in national defense, the quality of life, and the economic security and competitiveness of the nation; and partly because the selection of materials has increasingly become an integral part of almost every modern engineering design. Emphasis in the Materials Science Engineering curriculum is placed on the synthesis, characterization, and properties of advanced functional materials; analysis, selection, and design related to the use of materials; the application of computers to materials problems; and the presence of an interdisciplinary theme that allows a qualified student to combine any engineering major with the Materials Science Engineering major.

Mechanical Engineering considers the design, control, and motive power of fluid, thermal, and mechanical systems ranging from microelectronics to spacecraft to the human body. Specializations allow students to focus their technical electives in the areas of Aerospace Engineering, Energy Systems and Environmental Engineering, Flow Physics and Propulsion Systems, and Design of Mechanical Systems.

The School offers M.S. and Ph.D. degrees in Biomedical Engineering; Chemical and Biochemical Engineering; Civil Engineering; Electrical and Computer Engineering, with concentrations in Computer Engineering and Electrical Engineering; Engineering, with concentrations in Environmental Engineering, and Materials and Manufacturing Technology; Materials Science and Engineering; and Mechanical and Aerospace Engineering. Specialized research opportunities are available within each of these programs. In Biomedical Engineering, areas of research include micro/nanoscale biomedical devices for diagnostics and therapeutics, biophotonics, systems/synthetic bioengineering, tissue/organ engineering, cardiovascular engineering, cancer biotechnology, and neuroengineering. Bioreaction and bioreactor engineering, recombinant cell technology, and bioseparation processes are research areas in Biochemical Engineering. In Civil Engineering, research opportunities are provided in structural/earthquake engineering, reliability engineering, transportation systems engineering, environmental engineering, and water resources. Research opportunities in Electrical and Computer Engineering are available in the areas of parallel and distributed computer systems, VLSI design, computer architecture, image and signal processing, communications, control systems, and optical and solid-state devices. Research in combustion and propulsion sciences, laser diagnostics, supersonic flow, direct numerical simulation, computer-aided design, robotics, control theory, parameter identification, material processing, electron microscopy, and ceramic engineering are all available in Mechanical and Aerospace Engineering. The School also offers the M.S. degree in Engineering Management, a joint degree program with the Paul Merage School of Business; and the M.S. degree in Biotechnology Management, a joint degree program with the School of Biological Sciences and The Paul Merage School of Business.

Additional publications describing undergraduate and graduate academic study and research opportunities are available through The Henry Samueli School of Engineering, and the Departments of Biomedical Engineering, Chemical Engineering and Materials Science, Civil and Environmental Engineering, Electrical Engineering and Computer Science, and Mechanical and Aerospace Engineering.

### Degrees

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<tr>
<th>Program</th>
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<tbody>
<tr>
<td>Aerospace Engineering</td>
<td>B.S.</td>
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<tr>
<td>Biomedical Engineering</td>
<td>B.S., M.S., Ph.D.</td>
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<tr>
<td>Biomedical Engineering: Premedical</td>
<td>B.S.</td>
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<tr>
<td>Biotechnology Management</td>
<td>M.S.</td>
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<tr>
<td>Chemical and Biochemical Engineering</td>
<td>M.S., Ph.D.</td>
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<tr>
<td>Chemical Engineering</td>
<td>B.S.</td>
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<tr>
<td>Civil Engineering</td>
<td>B.S., M.S., Ph.D.</td>
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<tr>
<td>Computer Science and Engineering$^2$</td>
<td>B.S.</td>
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<tr>
<td>Computer Engineering</td>
<td>B.S.</td>
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<tr>
<td>Electrical and Computer Engineering</td>
<td>M.S., Ph.D.</td>
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<tr>
<td>Electrical Engineering</td>
<td>B.S.</td>
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<tr>
<td>Engineering Management$^3$</td>
<td>B.S., M.S., Ph.D.</td>
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<tr>
<td>Engineering Management$^4$</td>
<td>M.S.</td>
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<tr>
<td>Environmental Engineering</td>
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<tr>
<td>Materials Science and Engineering</td>
<td>M.S., Ph.D.</td>
</tr>
<tr>
<td>Materials Science Engineering</td>
<td>B.S.</td>
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Requirements for the Bachelor’s Degree

All students in The Henry Samueli School of Engineering must fulfill the following requirements.

All students must meet the University Requirements.

All students must meet the School Requirements:

The following are minimum subject-matter requirements for graduation:

Mathematics and Basic Science Courses: Students must complete a minimum of 48 units of college-level mathematics and basic sciences.

Engineering Topics Courses: Students must complete a minimum of 72 units of engineering topics. Engineering topics are defined as courses with applied content relevant to the field of engineering.

Design Units: All undergraduate Engineering courses indicate both a total and a design unit value. Design unit values are listed at the end of the course description. Each student is responsible for the inclusion of courses whose design units total that required by the program of study.

The Academic Plan and Advising Requirements: To remain affiliated with The Henry Samueli School of Engineering, all students enrolled in the School are required to meet annually with their designated faculty for advising and mentoring and to have an academic plan on file with the Student Affairs Office which has been approved by their academic counselor. Students who do not have a plan on file, or deviate from this plan without approval from an academic counselor will be subject to probation. Students on probation for two consecutive quarters who do not have a plan on file, or deviate from this plan without approval from an academic counselor will be subject to disqualification. Students who fail to meet with a faculty advisor each year will be subject to disqualification.

Duplication of Subject Material: Students who take courses which involve considerable duplication of subject material may not receive full graduation credit for all units thus completed.

Residence Requirement: In addition to the University residence requirement, at least 36 upper-division engineering units specified by each major must be completed successfully at University of California.

Variations: Variations from the general School degree requirements may be made subject to the approval of the faculty of the School. Students wishing to obtain variances should submit petitions to the School’s Student Affairs Office.

Undergraduate Study

Michael M Green, Associate Dean for Undergraduate Student Affairs
Student Affairs Office
305 Rockwell Engineering Center
949-824-4334

• Admissions
• Undergraduate Programs
• General Undergraduate Major in Engineering

Admissions

The sequential nature of the Engineering program and the fact that many courses are offered only once a year make it beneficial for students to begin their studies in the fall quarter. Applicants wishing to be admitted for the fall quarter, 2019, must have submitted their completed application forms during the priority filing period (August 1 - November 30, 2018).

High school students wishing to enter the UCI Engineering program must have completed four years of mathematics through pre-calculus or math analysis and are advised to have completed one year each of physics and chemistry. That preparation, along with honors courses and advanced placement courses, is fundamental to success in the Engineering program and is vital to receiving first consideration for admittance to an Engineering major during periods of restricted enrollments. Students applying for admission for fall quarter should complete their examination requirements during May or June of their junior year or during their senior year, but no later than the December test date. (Typically, this means that students will take the
SAT or the ACT Plus Writing Test in October or November. Applicants are strongly encouraged to take a math or science AP or SAT exam. Applicants should favor the Math Level 2 SAT Subject Test over the Math Level 1 Test. Applicants must apply for admission to a specific Engineering major or Engineering Undeclared.

If enrollment limitations make it necessary, unaccommodated Engineering applicants may be offered alternative majors at UCI.

Transfer students may be admitted to The Henry Samueli School of Engineering either from another major at UCI or from another college or university. A student seeking admission to The Henry Samueli School of Engineering from colleges and schools other than UCI must satisfy University requirements for admission with advanced standing and should complete appropriate prerequisites for their major of choice. Applicants should prioritize completing subject requirements (math, science, engineering) over completion of IGETC or UCI general education and lower-division requirements prior to transfer. IGTEC is not considered in transfer selection while subject requirements contribute directly to reducing time to graduate. Since requirements vary from major to major, those contemplating admission with advanced standing to the School should consult each Department’s Catalogue section and the UCI Office of Admissions and Relations with Schools, 949-824-6703, for the specific requirements of each program. All transfer students should arrange for early consultation with The Henry Samueli School of Engineering Student Affairs Office at 949-824-4334.

Change of Major: Students who wish to change their major to one offered by the School should contact the Engineering Student Affairs Office for information about change-of-major requirements, procedures, and policies. Information is also available at the UCI Change of Major Criteria website (http://www.changeofmajor.uci.edu).

Engineering Gateway Freshman-Year Curriculum

Students who know that they want to major in engineering but who are unsure of the specific major should apply for the Engineering Gateway Curriculum and follow the Sample Engineering Gateway Curriculum. Students following the Engineering Gateway Curriculum are required to meet with an academic advisor every quarter and are strongly encouraged to declare a major as soon as possible and then follow the appropriate sample program of study for that major.

Sample Engineering Gateway Curriculum - Freshman

<table>
<thead>
<tr>
<th>Freshman</th>
<th>Winter</th>
<th>Spring</th>
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<tbody>
<tr>
<td>Fall</td>
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<tr>
<td>MATH 2A</td>
<td>MATH 2B</td>
<td>MATH 2D</td>
</tr>
<tr>
<td>ENGR 7A</td>
<td>ENGR 7B</td>
<td>PHYSICS 7D</td>
</tr>
<tr>
<td>ENGR 1A</td>
<td>CHEM 1B</td>
<td>PHYSICS 7LD</td>
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<tr>
<td>or</td>
<td>PHYSICS 7C</td>
<td>Select one of the following:</td>
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<tr>
<td>CHEM 1A</td>
<td>PHYSICS 7LC</td>
<td>CHEM 1C-1LC</td>
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</tbody>
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Select one of the following:

EECS 10
EECS 12
ENGRMAE 10
I&C SCI 32

1 Students who choose to major in Biomedical Engineering or Biomedical Engineering: Premedical should enroll in BME 1 in the fall quarter of the sophomore year. Students who choose to major in Computer Engineering should enroll in EECS 20 by the spring or summer quarter preceding their sophomore year.

2 Students who are considering the Computer Science and Engineering major should enroll in I&C SCI 32

Students who choose certain majors during the first year may replace Chemistry courses with required major courses.

Students should choose a major by the end of the spring quarter of their freshman year or earlier. Some modification in the program of study might be appropriate if the student chooses a major before the end of the freshman year. In any case, when the major is chosen, the student must meet immediately with an academic counselor to plan the program of study.

Undergraduate Programs

Specific information about courses fulfilling School and major requirements can be found in the department sections. Note that some majors require more units than the School requirements.

Aerospace Engineering
Biomedical Engineering
Biomedical Engineering: Premedical
Chemical Engineering
Civil Engineering
Computer Engineering
Computer Science and Engineering
Electrical Engineering
Minors/Concentrations of Interest to Engineers

Minor in Earth and Atmospheric Sciences
The minor in Earth and Atmospheric Sciences focuses on the application of physical, chemical, and biological principles to understanding the complex interactions of the atmosphere, ocean, and land through climate and biogeochemical cycles. See the Department of Earth System Science in the School of Physical Sciences section of this Catalogue for more information.

Minor in Global Sustainability
The interdisciplinary minor in Global Sustainability trains students to understand the changes that need to be made in order for the human population to live in a sustainable relationship with the resources available on this planet. See the Interdisciplinary Studies section of this Catalogue for more information.

Concentration: Engineering and Computer Science in the Global Context
The globalization of the marketplace for information technology services and products makes it likely that The Henry Samueli School of Engineering graduates will work in multicultural settings or be employed by companies with extensive international operations, or customer bases. The goal of the concentration is to help students develop and integrate knowledge of the history, language, and culture of a country or geographic region outside the United States, through course work both at UCI and an international host campus, followed by a technology-related internship in the host country.

All of The Henry Samueli School of Engineering majors in good standing may propose an academic plan that demonstrates the ability to complete the concentration (a minimum of eight courses) and other requirements for graduation in a reasonable time frame. It is expected that a student's proposal will reflect a high degree of planning that includes the guidance of academic counselors and those at the UCI Study Abroad Center regarding course selection, as well as considerations related to internship opportunities, housing, and financial aid. Each student's proposed program of study must be approved by the Associate Dean for Student Affairs in The Henry Samueli School of Engineering. The Associate Dean will be available to assist qualified students with the development of a satisfactory academic plan, as needed.

The concentration consists of the following components:
1. A minimum of eight courses at UCI or at the international campus with an emphasis on the culture, language (if applicable and necessary), history, literature of the country that corresponds to the international portion of the program, international law, international labor policy, global issues, global institutions, global conflict and negotiation, and global economics;
2. A one- or two-semester sequence of technical courses related to the major and, possibly, culture, history, and literature courses taken at an international university;
3. A two-month or longer technical internship experience in the same country as the international educational experience.

More information about the requirements for the concentration is available in The Henry Samueli School of Engineering Student Affairs Office.

The concentration in Engineering and Computer Science in the Global Context is open to students in Aerospace Engineering, Biomedical Engineering, Biomedical Engineering: Premedical, Chemical Engineering, Civil Engineering, Computer Engineering, Engineering (General), Electrical Engineering, Environmental Engineering, Materials Science Engineering, and Mechanical Engineering.

Academic Advising
Academic advising is available from academic counselors and peer advisors in the School’s Student Affairs Office, 305 Rockwell Engineering Center, and from faculty advisors. Students must realize, however, that ultimately they alone are responsible for the planning of their own program and for satisfactory completion of the graduation requirements. Students are encouraged to consult with the academic counselors in the Engineering Student Affairs Office whenever they desire to change their program of study. All Engineering majors are required to meet with their faculty advisor at least once each year.

Some engineering students will need more than four years to obtain their B.S., particularly if part-time employment or extracurricular activities make heavy demands on their time. Normally, such students can stay on track, and are encouraged to do so, by enrolling in summer sessions at UCI or at other institutions when a petition has been approved in advance.

High-achieving students may declare a second major. Early consultation with the School is advisable.

Required courses may be replaced by other courses of equivalent content if the student substantiates the merits of the courses in the program of study and obtains prior approval from faculty in the School.

Students should be aware that most Engineering courses require the completion of prerequisites. The sample programs shown in each departmental description constitute preferred sequences which take into account all prerequisites.
School policy does not permit the deletion of Engineering courses after the second week or addition of Engineering courses after the second week of the quarter without the Associate Dean's approval.

Undergraduate students who have high academic standing, who have completed the necessary prerequisites, and who have obtained permission from the School may qualify to take certain graduate-level courses.

Students are required to complete UCI’s lower-division writing requirement (see the Requirements for a Bachelor’s Degree section) during the first two years. Thereafter, proficiency in writing and computing (using a higher-level language such as Python, C, C++, Java, or MATLAB) is expected in all Engineering courses.

The Pass/Not Pass option is available to encourage students to enroll in courses outside their major field. Pass/Not Pass option cannot be used to satisfy specific course requirements of the students school and major. Students must take courses to fulfill the UC Entry Level Writing requirement for a grade. For more complete information, see the Academic Regulations and Procedures section of this Catalogue.

Career Advising

The UCI Career Center provides services to students and alumni including career counseling, information about job opportunities, a career library, and workshops on resume preparation, job search, and interview techniques. See the Career Center section for additional information. In addition, special career planning events are held throughout the year including an annual Career Fair. Individual career counseling is available, and students have access to the Career Library which contains information on graduate and professional schools in engineering, as well as general career information.

Proficiency Examinations

A student may take a course by examination with the approval of the faculty member in charge of the course and the Dean of the School. Normally, ability will be demonstrated by a written or oral examination; if a portion of the capability involves laboratory exercises, the student may be required to perform experiments as well. The proficiency examination is not available for any course a student has completed at UCI.

Honors

Graduation with Honors. Undergraduate honors at graduation in The Henry Samueli School of Engineering are computed by using 50 percent of the overall UCI GPA and 50 percent of the upper-division Engineering GPA. A general criterion is that students must have completed at least 72 units in residence at a University of California campus. Approximately 2 percent of the graduating class shall be awarded summa cum laude, 4 percent magna cum laude, and 10 percent cum laude, with no more than 16 percent being awarded honors. Other important factors are considered visit at Honors Recognition.

Dean's Honor List. The quarterly Dean's Honor List is composed of students who have received a 3.5 GPA while carrying a minimum of 12 graded units.

Gregory Bogaczyk Memorial Scholarship. This scholarship was established in memory of Gregory Bogaczyk, a former UCI Mechanical Engineering student, and is contributed by the Bogaczyk family and friends. An award is given each year to a junior or senior Mechanical Engineering student.

Haggai Memorial Endowed Scholarship. This memorial fund was established in honor of Ted Haggai, an electrical engineer. This scholarship is awarded to an outstanding senior electrical engineering student and member of Tau Beta Pi. Primary consideration will be given to members of Tau Beta Pi who have contributed outstanding service to both UCI and The Henry Samueli School of Engineering.

Christine Jones Memorial Scholarship. This scholarship was established in memory of Christine Jones, an Electrical Engineering graduate, Class of 1989. The primary focus of this scholarship is to provide financial support to a female undergraduate student in The Henry Samueli School of Engineering.

Deborah and Peter Pardoen Memorial Scholarship. This scholarship is awarded each year to a graduating senior in Mechanical Engineering or in Aerospace Engineering. The scholarship is based on outstanding service to The Henry Samueli School of Engineering and the community.

Henry Samueli Endowed Scholarship. This premier scholarship, established by Henry Samueli, is awarded to outstanding freshmen and transfer students in The Henry Samueli School of Engineering. Recipients are chosen by the School based on their academic excellence. The award is renewable up to four years for freshmen and up to two years for transfer students.

Additional awards in other categories are made throughout the academic year.

Office of Access and Inclusion

200A Rockwell Engineering Center; 949-824-7134
Sharnnia Artis, Assistant Dean for Access and Inclusion

The Office of Access and Inclusion (OAI) facilitates and supports the recruitment, retention, and graduation of undergraduate and graduate students from historically excluded populations who are currently underrepresented in the Samueli School of Engineering and the Donald Bren School of Information and Computer Sciences. Services include mentoring, tutoring, career and academic workshops and coaching, and assistance for students looking to conduct undergraduate research or prepare for graduate school.
Special Programs and Courses

Campuswide Honors Program
The Campuswide Honors Program is available to selected high-achieving students from all academic majors from their freshman through senior years. For more information contact the Campuswide Honors Program, 1200 Student Services II; 949-824-5461; honors@uci.edu; or visit the Campuswide Honors Program website (http://www.honors.uci.edu).

Engineering 199
Every undergraduate student in The Henry Samueli School of Engineering has the opportunity to pursue independent research under the direct supervision of a professor in the School. Interested students should consult with a faculty member to discuss the proposed research project. If the project is agreed upon, the student must fill out a 199 Proposal Form and submit it to the Engineering Student Affairs Office.

Undergraduate Research Opportunities Program
The Undergraduate Research Opportunities Program (UROP) encourages and facilitates research and creative activities by undergraduates. Research opportunities are available not only from every discipline, interdisciplinary program, and school, but also from many outside agencies, including national laboratories, industrial partners, and other universities. UROP offers assistance to students and faculty through all phases of the research activity: proposal writing, developing research plans, resource support, conducting the research and analyzing data, and presenting results of the research at the annual spring UCI Undergraduate Research Symposium. Calls for proposals are issued in the fall and spring quarters. Projects supported by UROP may be done at any time during the academic year and/or summer, and the research performed must meet established academic standards and emphasize interaction between the student and the faculty supervisor. In addition, all students participating in faculty-guided research activities are welcome to submit their research papers for faculty review and possible publication in the annual UCI Undergraduate Research Journal. For more information, contact the UROP Office, 1100 Student Services II; 949-824-4189; urop@uci.edu; or visit the Undergraduate Research Opportunities Program website (http://www.urop.uci.edu).

Accelerated M.S. or Ph.D. Status Program in The Henry Samueli School of Engineering
Exceptionally promising UCI undergraduate Engineering students may, during their junior or senior year, petition for streamlined admissions into a graduate program within The Henry Samueli School of Engineering. Accelerated M.S. Status would allow a student to petition for exemption from UCI’s Graduate Record Examination (GRE) requirement for graduate school admission. (The exemption applies only to current UCI students applying for admission to one of the M.S. programs in The Henry Samueli School of Engineering; other graduate schools may still require the GRE.) A current UCI undergraduate student whose ultimate goal is a Ph.D. may apply for Accelerated Status, however, a GRE score must be submitted.

Accelerated Status applicants would in all other ways be evaluated in the same manner as other applicants to the School’s graduate programs. Occasionally, a candidate for Accelerated Status may be required by the faculty to submit GRE scores in support of the graduate application.

Students who successfully petition for Accelerated Status, upon matriculation to the graduate degree program, may petition to credit toward the M.S. degree up to 18 units (with a grade of B or better) of graduate-level course work completed in excess of requirements for the UCI bachelor’s degree.

Visit the UCI Undergraduate Accelerated Status website (https://www.eng.uci.edu/admissions/graduate/accelerated-status-program) for more detailed information about this program and its eligibility requirements.

UC Education Abroad Program
Engineering students may participate in a number of programs which offer unique opportunities for education and training abroad. The University’s Education Abroad Program (UCEAP) offers engineering course work for UCI academic credit at a number of universities. Some of the UCEAP-affiliated engineering schools require proficiency in the host country’s language, while others are English speaking. Study abroad may postpone the student’s graduation for one or two quarters, depending primarily on the student’s language preparation (which can begin in the freshman year), but the added experience can add to the student’s maturity and professional competence. UCEAP students pay regular UCI fees and tuition and keep any scholarships they may have. Visit the Study Abroad Center website (http://www.studyabroad.uci.edu) for additional information.

Student Participation and Organizations
Faculty and committee meetings (except those involving personnel considerations) are open meetings; in addition to designated student representatives, all students are encouraged and expected to participate in the development of School policy. Student evaluation of the quality of instruction for each course is requested each quarter.

Engineering students may join any of a number of student organizations. Most of these organizations are professionally oriented and in many instances are local chapters of national engineering societies. A primary function of these groups is to provide regular technical and social meetings for students with common interests. Most of the groups also participate in the annual Engineering Week activities and in other School functions.

Associated General Contractors (AGC). A student chapter of the national organization, ACG at UCI is an academic engineering club for students interested in the construction field.

American Indian Science & Engineering Society (AISES). The mission of AISES is to increase the representation of American Indians in engineering, science, and technology. Chapters emphasize education as a tool that will facilitate personal and professional growth opportunities through mentor programs, leadership training, scholarships, conferences, and summer job opportunities.
American Institute of Aeronautics and Astronautics (AIAA). The AIAA is a technical society of 40,000 professional and student members devoted to science and engineering in the field of aerospace. The local chapter’s primary activities include seminars, tours of industries, and mentoring for students by professional members.

American Institute of Chemical Engineers (AIChE). AIChE, a student chapter of the national organization, provides Chemical Engineering majors with the opportunity to interact with faculty and professionals in the field.

American Society for Civil Engineers (ASCE). One of the larger engineering clubs, ASCE at UCI is a student chapter of the national organization. The ASCE focuses its efforts on interactions with professional engineers, sponsorship of Engineering Week activities, and participation in the annual ASCE Southwest Conference.

American Society for Materials (ASM). The student chapter of ASM at UCI provides the opportunity for Materials Science Engineering (MSE) students to meet engineers and scientists from local industry, attend seminars organized by the Orange Coast Chapter of ASM International, and organize discussion sessions that focus on progress and advances in the MSE field and that promote interactions between MSE students and materials faculty.

American Society of Mechanical Engineers (ASME). The student chapter of ASME at UCI provides the opportunity for Mechanical Engineering majors to meet with professors, organize social events, and participate in events and competitions supported by the ASME national organization.

Biomedical Engineering Society (BMES). The student chapter of BMES at UCI is an academic club for students in the field of Biomedical Engineering.

Chi Epsilon. This organization is a national engineering honor society which is dedicated to the purpose of promoting and maintaining the status of civil engineering as an ideal profession. Chi Epsilon was organized to recognize the characteristics of the individual that are fundamental to the successful pursuit of an engineering career.

Electric Vehicle Association/UCI (EVA/UCI). EVA/UCI gives students an opportunity for hands-on work on electric car conversions coupled with design experience.

Engineering Student Council (ESC). The ESC is the umbrella organization that provides a voice for all Engineering student chapters. A significant activity of the Council is organizing UCI’s annual Engineering Week celebration.

Engineers Without Borders (EWB). This humanitarian organization combines travel with the idea that engineers can play an instrumental role in addressing the world’s assorted challenges. Through the implementation of equitable, economical, and sustainable engineering projects, EWB-UCI works to improve quality of life within developing communities abroad.

Eta Kappa Nu. A student chapter of the National Electrical Engineering Honor Society, Eta Kappa Nu’s purpose is to promote creative interaction between electrical engineers and give them the opportunity to express themselves uniquely and innovatively to project the profession in the best possible manner.

Filipinos Unifying Student-Engineers in an Organized Network (FUSION). Fusion is the merging of diverse, distinct, or separate elements into a unified whole. The mission of FUSION is to promote the academic and professional development of student engineers by providing an organized network of support.

Institute of Electrical and Electronic Engineers (IEEE). A student chapter of a multinational organization, IEEE at UCI encompasses academic, professional, and social activities.

Institute of Transportation Engineers (ITE). ITE is a student chapter of a national group of transportation engineering professionals. Offering opportunities to meet both professionals and other students, ITE focuses its activities on an annual project with practical applications.

Mexican-American Engineers and Scientists (MAES) / Latinos in Science and Engineering. Open to all students, MAES is a student and professional organization with the purpose of aiding students in their academic, professional, and social endeavors.

National Society of Black Engineers (NSBE). The NSBE, with almost 6,000 members, is one of the largest student-managed organizations in the country. The Society is dedicated to the realization of a better tomorrow through the development of intensive programs to increase the recruitment, retention, and successful graduation of underrepresented students in engineering and other technical majors.

Omega Chi Epsilon. The student chapter of the National Chemical Engineering Honor Society aims to recognize and promote high scholarship, original investigation, and professional service in chemical engineering.

Phi Sigma Rho. This national sorority is open to women in engineering, engineering technology, and STEM majors. Its purpose is to provide social opportunities, promote academic excellence, and provide encouragement and friendship.

Pi Tau Sigma. The mechanical engineering honor society, Pi Tau Sigma, is committed to recognizing those of high achievement. The goal of the organization is to promote excellence in academic, professional, and social activities.

Sigma Gamma Tau. The aerospace engineering honor society, Sigma Gamma Tau, is committed to recognizing those of high achievement. The goal of the organization is to promote excellence in academic, professional, and social activities.
Society of Hispanic Professional Engineers (SHPE). SHPE is both a student and professional organization. The UCI SHPE chapter works to recruit, retain, and graduate Latino engineers by providing a comprehensive program which includes high school visitations, coordinated study sessions, and industry speakers and tours. At the professional level there are opportunities for career positions and scholarships for members who are enrolled in undergraduate and graduate engineering and computer science programs.

Society of Automotive Engineers (SAE). Members of the SAE chapter at UCI participate in technical expositions, mini-Baja buggy races, student competitions, and social activities.

Society of Women Engineers (SWE). SWE is a national service organization dedicated to the advancement of women in engineering. UCI’s student chapter encourages academic and social support, and membership is open to both men and women in technical majors interested in promoting camaraderie and in helping to make engineering study a positive experience.

Structural Engineers Association of Southern California (SEAOSC). The UCI student chapter of SEAOSC introduces students to the field of structural engineering through tours, speakers, and SEAOSC dinners with professional members of the organization.

Sustainable Energy Technology Club (SETC). With the common theme of energy, club members explore how science and technology can be used as a driving force behind making changes in society with respect to a cleaner environment and less wasteful lifestyles.

Tau Beta Pi. The national Engineering honor society, Tau Beta Pi acknowledges academic excellence in the wide variety of engineering disciplines. Tau Beta Pi at UCI sponsors community service activities, social events, and technical and nontechnical seminars.

Theta Tau. This is a national fraternity of men and women studying engineering. The goals are to promote the social and professional development of its members during and after their college years.

Triangle. This national social fraternity is open to men majoring in engineering, architecture, and the physical, mathematical, biological, and computer sciences. Its purpose is to develop balanced men who cultivate high moral character, foster lifelong friendships, and live their lives with integrity.

General Undergraduate Major in Engineering
305 Rockwell Engineering Center; 949-824-4334

The Henry Samueli School of Engineering offers a general undergraduate major in Engineering to upper-division students who wish to pursue broad multidisciplinary programs of study or who wish to focus on a special area not offered in the four departments. Examples of other areas that may be of interest are biochemical engineering, electromechanical engineering, project management, or hydrology. The program of study in any area, aside from the established specializations, is determined in consultation with a faculty advisor.

Faculty in the Departments of Biomedical Engineering, Chemical Engineering and Materials Science, Civil and Environmental Engineering, Electrical Engineering and Computer Science, and Mechanical and Aerospace Engineering also teach courses in the major in Engineering program.

Admissions

The general major in Engineering is only open to junior-standing students who have completed the required lower-division courses with a high level of achievement. Freshmen are not eligible to apply for this major. The sequential nature of the Engineering program and the fact that many courses are offered only once a year make it beneficial for students to begin their studies in the fall quarter.

Transfer Students: The general Engineering major is a specialized program for students who are seeking careers in areas other than traditional engineering disciplines and is open to upper-division students only. Preference will be given to junior-level applicants with the highest grades overall, and who have satisfactorily completed the following required courses: one year of approved calculus, one year of calculus-based physics with laboratories (mechanics, electricity and magnetism), one course in computational methods (e.g., C, C++), and one year of general chemistry (with laboratory).

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 Engineering

Credit for at least 180 units, and no more than 196 units. All courses must be approved by a faculty advisor and the Associate Dean of Student Affairs prior to enrollment in the program.

All students must meet the University Requirements.
All students must meet the School Requirements.

Major Requirements

Mathematics and Basic Science Courses: MATH 2A-MATH 2B-MATH 2D, MATH 2E, MATH 3A, and MATH 3D, PHYSICS 7C, PHYSICS 7LC, PHYSICS 7D, and PHYSICS 7LD. With the approval of a faculty advisor and the Associate Dean, students select all additional Mathematics and Basic Science courses.
Engineering Topics Courses: ENGRMAE 10 or equivalent. With the approval of a faculty advisor and the Associate Dean, students select all additional Engineering Topics courses.

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.

Program of Study

Students should keep in mind that the program for the major in Engineering is based upon a rigid set of prerequisites, beginning with adequate preparation in high school mathematics, physics, and chemistry. Therefore, the course sequence should not be changed except for the most compelling reasons. Students must have their programs approved by an academic counselor in Engineering. A sample program of study is available in the Student Affairs Office.

Graduate Study

Fadi J. Kurdahi, Associate Dean for Graduate and Professional Studies
Graduate Student Affairs Office
204 Rockwell Engineering Center
949-824-8090

Admissions

For information on requirements for admission to graduate study at UCI, contact the appropriate Engineering department, concentration director, or the Graduate Student Affairs Office in The Henry Samueli School of Engineering. Additional information is available in the Catalogue's Graduate Division section. Admission to graduate standing in The Henry Samueli School of Engineering is generally accorded to those possessing a B.S. in engineering or an allied field obtained with an acceptable level of scholarship from an institution of recognized standing. Those seeking admission without the prerequisite scholarship record may, in some cases, undertake remedial work; if completed at the stipulated academic level, they will be considered for admission. Those admitted from an allied field may be required to take supplementary upper-division courses in basic engineering subjects. The Graduate Record Examination (GRE) General Test is required of all applicants.

Financial Support

Teaching assistantships and fellowships are available to qualified applicants. (Applicants should contact the Department or concentration director to which they are applying for information.) Research assistantships are available through individual faculty members. Although not required, it is beneficial for applicants to contact the faculty member directly to establish the potential for research support. Early applications have a stronger chance for financial support.

Part-Time Study

Those students who are employed may pursue the M.S. on a part-time basis, carrying fewer units per quarter. Since University residency requirements necessitate the successful completion of a minimum number of units in graduate or upper-division work in each of at least three regular University quarters, part-time students should seek the advice of a counselor in The Henry Samueli School of Engineering Graduate Student Affairs Office and the approval of the Graduate Advisor in their program. M.S. programs must be completed in four calendar years from the date of admission. Students taking courses in UCI Division of Continuing Education prior to enrollment in a graduate program should consult the following section on Transfer of Courses.

Transfer and Substitution of Courses

Upon petition, a limited number of upper-division undergraduate or graduate-level courses taken through UCI Division of Continuing Education, at another UC campus, or in another accredited university may be credited toward the M.S. after admission. The applicability of transfer or substitution courses must be approved by the student’s department, the School’s Associate Dean, and the Graduate Dean of the University, in accordance with Academic Senate regulations. Also in accordance with UC Academic Senate policy, transfer credit for the M.S. cannot be used to reduce the minimum requirement in strictly graduate (200 series) courses.

Graduate Programs

For specific information about program requirements, click on the links below.

Biomedical Engineering
Biotechnology Management
Chemical and Biochemical Engineering
Civil Engineering
Electrical and Computer Engineering (Concentration in Computer Engineering)
Electrical and Computer Engineering (Concentration in Electrical Engineering)
Engineering (Concentration in Environmental Engineering)
Engineering (Concentration in Materials and Manufacturing Technology)
Engineering Management
Materials Science and Engineering
The M.S. and Ph.D. in Engineering with a Concentration in Materials and Manufacturing Technology

204 Rockwell Engineering Center; 949-824-8090
Chin C. Lee, Director and Graduate Advisor

Materials and Manufacturing Technology (MMT) is concerned with the generation and application of knowledge relating the composition, structure, and processing of materials to their properties and applications, as well as the manufacturing technologies needed for production. During the past two decades, MMT has become an important component of modern engineering education, partly because of the increased level of sophistication required of engineering materials in a rapidly changing technological society, and partly because the selection of materials has increasingly become an integral part of almost every modern engineering design. In fact, further improvements in design are now viewed more and more as primarily materials and manufacturing issues. Both the development of new materials and the understanding of present-day materials demand a thorough knowledge of basic engineering and scientific principles including, for example, crystal structure, mechanics, mechanical behavior, electronic, optical and magnetic properties, thermodynamics, phase equilibria, heat transfer, diffusion, and the physics and chemistry of solids and chemical reactions.

The field of MMT ranks high on the list of top careers for scientists and engineers. The services of these engineers and scientists are required in a variety of engineering operations dealing, for example, with design of semiconductors and optoelectronic devices, development of new technologies based on composites and high-temperature materials, biomedical products, performance (quality, reliability, safety, energy efficiency) in automobile and aircraft components, improvement in nondestructive testing techniques, corrosion behavior in refineries, radiation damage in nuclear power plants, fabrication of steels, and construction of highways and bridges.

Subjects of interest in Materials and Manufacturing Technology cover a wide spectrum, ranging from metals, optical and electronic materials to superconductive materials, ceramics, advanced composites, and biomaterials. In addition, the emerging new research and technological areas in materials are in many cases interdisciplinary. Accordingly, the principal objective of the graduate curriculum is to integrate a student’s area of emphasis—whether it be chemical processing and production, electronic and photonic materials and devices, electronic manufacturing and packaging, or materials engineering—into the whole of materials and manufacturing technology. Such integration will increase familiarity with other disciplines and provide students with the breadth they need to face the challenges of current and future technology.

Students with a bachelor’s degree may pursue either the M.S. or Ph.D. in Engineering with a concentration in Materials and Manufacturing Technology (MMT). If students choose to enter the Ph.D. program directly, it is a requirement that they earn an M.S. along the way toward the completion of their Ph.D.

Faculty
Ozdal Boyraz (silicon photonics, nonlinear optics in silicon, cascaded cavity silicon Raman lasers)
Peter J. Burke (quantum electronics, high-speed semiconductor technology)
Zhongping Chen (optical sensor and imaging, MEMS and biophotonic system, and biomedical devices)
James C. Earthman (fatigue behavior and cyclic damage, automated materials testing, high-temperature fracture, biomaterials, cellular networks)
Franco De Flaviis (microwave materials and devices, MEMS devices and fabrication processes)
Michelle Khine (manufacturing and scalability of micro and nanotechnologies for in vitro diagnostics, in vivo applications, and wearable electronics)
John C. LaRue (fluid mechanics, micro-electrical-mechanical systems (MEMS), turbulence, heat transfer, instrumentation)
Abraham Lee (micro and nanofluidic chips, droplet-based reactors for bioassays and materials synthesis, cell and biomolecular based sensors, nanoparticles and vesicles for drug delivery and targeted therapeutics)
Chin C. Lee, Director (electronic packaging, fluxless bonding technology, thermal design and management, semiconductor devices, and microwaves)
Jae Ho Lee (heat transfer in microdevices and nanomaterials, phonon transport modeling, electrothermal characterization, thermomechanical optimization, thermoelectrics, and phononics)
Henry P. Lee (optoelectronic materials, growth, and devices)
Guann Pyng Li (optoelectronic devices, integrated circuit fabrication and testing, high-speed semiconductor technology)
Michael McCarthy (computer-aided design, analysis and synthesis of mechanical movement, and cyber-physical systems)

Marc J. Madou (fundamental aspects of micro/nano-electro-mechanical systems [MEMS/NEMS], biosensors, nanofluidics, biomimetics)

Martha L. Mecartney (electron microscopy, ceramics, interfacial engineering)

Farghalli A. Mohamed (mechanical properties, creep, superplasticity, correlations between property and microstructure)

Ayman S. Mosallam (polymer composites, nano-composites, experimental mechanics, numerical Simulation, durability, composite joints, health monitoring, non-destructive testing, repair, and creep)

Daniel R. Mumm (thermo-mechanical behavior of materials, interfaces and microstructure, materials for power and propulsion, cellular materials, morphing structures, micro/nano-mechanics)

Regina Ragan (self-assembly, nanoelectronics, nanophotonics, chemical and biological sensors, organic/inorganic interfaces and nanofabrication)

Timothy J. Rupert (mechanical behavior, nanomaterials, structure-property relationships, structural evolution, grain boundaries and interfaces, electron microscopy)

Andrei M. Shkel (design, advanced control, diagnostics, and fabrication of integrated microelectromechanical systems [MEMS], applications in inertial, optical, and biomedical system)

Frank G. Shi (optoelectronics packaging, packaging materials, photonic glass and nanocomposites)

Lizhi Sun (CEE) (micromechanics and nanomechanics, dislocation dynamics, composites and thin films, multiscale modeling, elastography)

William Tang (wireless micro implants for neural prosthesis, platforms for micro- and nano-scale single-cell biomedical diagnosis, micro biomechanics on organisms, tissues, and cells, with emphases on cardiomyocytes, bone marrow stem cells, cancer cells, neurons, and malaria-infected red blood cells)

Chen S. Tsai (integrated optic devices and circuits, ferromagnetic materials; device and fabrication, ultrasonic nozzle technology for nanoparticles)

Lorenzo Valdevit (multifunctional sandwich structures, thermal protection systems, morphing structures, active materials, MEMS, electronic packaging, cell mechanics)

Yoonjin Won (multiphase heat transfer at the nanoscale with the development of innovative materials to address thermal challenges in modern electronics and energy application)

Albert Yee (nanofabrication of soft materials, physics of polymer thin films, nanomechanical properties of polymers, ultra-low k dielectrics, fracture and toughening of polymer nanocomposites)

**Recommended Background**

Given the nature of Materials and Manufacturing Technology as an interdisciplinary program, students having a background and suitable training in either Materials, Engineering (Biomedical, Civil, Chemical, Electrical, and Mechanical), or the Physical Sciences (Physics, Chemistry, Geology) are encouraged to participate. Recommended background courses include an introduction to materials, thermodynamics, mechanical properties, and electrical/optical/magnetic properties. A student with an insufficient background may be required to take remedial undergraduate courses following matriculation as a graduate student.

**Core Requirement**

Because of the interdepartmental nature of the concentration, it is important to establish a common foundation in Materials and Manufacturing Technology (MMT) for students from various backgrounds. This foundation is sufficiently covered in MMT courses that are listed below and that deal with the following topics: ENGRMSE 200 Crystalline Solids: Structure, Imperfections, and Properties; ENGRMAE 252 Fundamentals of Microfabrication or ENGR 265 Advanced Manufacturing; ENGRMAE 259 Mechanical Behavior of Solids - Atomistic Theories; BME 261 Biomedical Microdevices. Core courses must be completed with a grade of B (3.0) or better.

**Electives**

Electives are grouped into four areas of emphasis.

**Chemical Processing and Production:**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHEM 213</td>
<td>Chemical Kinetics</td>
</tr>
<tr>
<td>CBEMS 210</td>
<td>Reaction Engineering</td>
</tr>
<tr>
<td>CBEMS 220</td>
<td>Transport Phenomena</td>
</tr>
<tr>
<td>CBEMS 230</td>
<td>Applied Engineering Mathematics I</td>
</tr>
<tr>
<td>CBEMS 240</td>
<td>Advanced Engineering Thermodynamics</td>
</tr>
<tr>
<td>CBEMS 243</td>
<td>Chemistry and Technology for the Nuclear Fuel Cycle</td>
</tr>
<tr>
<td>Course Code</td>
<td>Course Title</td>
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</tr>
<tr>
<td>ENGRCEE 262</td>
<td>Environmental Chemistry II</td>
</tr>
<tr>
<td>ENGRCEE 265</td>
<td>Physical-Chemical Treatment Processes</td>
</tr>
<tr>
<td>ENGRCEE 266</td>
<td>Drinking Water and Wastewater Biotechnology</td>
</tr>
<tr>
<td>ENGRCEE 276</td>
<td>Hydrology</td>
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</tbody>
</table>

**Electronic and Photonic Materials and Devices:**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
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</thead>
<tbody>
<tr>
<td>BME 210</td>
<td>Molecular and Cellular Engineering</td>
</tr>
<tr>
<td>BME 225</td>
<td>Tissue and Organ Biophotonics</td>
</tr>
<tr>
<td>BME 251</td>
<td>Engineering Medical Optics</td>
</tr>
<tr>
<td>CBEMS 242A</td>
<td>Physical and Geometrical Optics</td>
</tr>
<tr>
<td>EECS 174</td>
<td>Semiconductor Devices</td>
</tr>
<tr>
<td>EECS 176</td>
<td>Fundamentals of Solid-State Electronics and Materials</td>
</tr>
<tr>
<td>EECS 188</td>
<td>Optical Electronics</td>
</tr>
<tr>
<td>EECS 277A</td>
<td>Advanced Semiconductor Devices I</td>
</tr>
<tr>
<td>EECS 277B</td>
<td>Advanced Semiconductor Devices II</td>
</tr>
<tr>
<td>EECS 277C</td>
<td>Nanotechnology</td>
</tr>
<tr>
<td>EECS 285A</td>
<td>Optical Communications</td>
</tr>
<tr>
<td>EECS 285B</td>
<td>Lasers and Photonics</td>
</tr>
<tr>
<td>EECS 280A</td>
<td>Advanced Engineering Electromagnetics I</td>
</tr>
<tr>
<td>EECS 280B</td>
<td>Advanced Engineering Electromagnetics II</td>
</tr>
<tr>
<td>ENGRMAE 220</td>
<td>Conduction Heat Transfer</td>
</tr>
<tr>
<td>ENGRMAE 221</td>
<td>Convective Heat and Mass Transfer</td>
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</tbody>
</table>

**Biomedical and Electronic Manufacturing:**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
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</thead>
<tbody>
<tr>
<td>BME 222</td>
<td>Biofluid Mechanics</td>
</tr>
<tr>
<td>BME 251</td>
<td>Engineering Medical Optics</td>
</tr>
<tr>
<td>BME 260</td>
<td>Microfluids and Lab-On-A-Chip</td>
</tr>
<tr>
<td>BME 262</td>
<td>Microimplants</td>
</tr>
<tr>
<td>CBEMS 280</td>
<td>Optoelectronics Packaging</td>
</tr>
<tr>
<td>EECS 279/ENGRMAE 249</td>
<td>Micro-Sensors and Actuators</td>
</tr>
<tr>
<td>ENGRMAE 212</td>
<td>Engineering Electrochemistry: Fundamentals and Applications</td>
</tr>
<tr>
<td>ENGRMAE 242</td>
<td>Robotics</td>
</tr>
<tr>
<td>ENGRMAE 247/EECS 278</td>
<td>Micro-System Design</td>
</tr>
<tr>
<td>ENGRMAE 250</td>
<td>Biorobotics</td>
</tr>
<tr>
<td>ENGRMAE 253</td>
<td>Advanced BIOMEMS Manufacturing Techniques</td>
</tr>
</tbody>
</table>

**Materials Engineering:**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
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</thead>
<tbody>
<tr>
<td>CHEM 225</td>
<td>Polymer Chemistry: Synthesis and Characterization of Polymers</td>
</tr>
<tr>
<td>CBEMS 219</td>
<td>Biomaterials: Structural Biology and Assembly</td>
</tr>
<tr>
<td>CBEMS 241</td>
<td>Nano-Scale Materials and Applications</td>
</tr>
<tr>
<td>ENGRCEE 242</td>
<td>Advanced Strength of Materials</td>
</tr>
<tr>
<td>ENGRCEE 243</td>
<td>Mechanics of Composite Materials</td>
</tr>
<tr>
<td>ENGRCEE 254</td>
<td>Advanced Reinforced Concrete Behavior and Design</td>
</tr>
<tr>
<td>ENGRCEE 255</td>
<td>Advanced Behavior and Design of Steel Structures</td>
</tr>
<tr>
<td>ENGRMAE 212</td>
<td>Engineering Electrochemistry: Fundamentals and Applications</td>
</tr>
<tr>
<td>ENGRMAE 224</td>
<td>Advanced Transport Phenomena</td>
</tr>
<tr>
<td>ENGRMAE 230A</td>
<td>Inviscid Incompressible Fluid Mechanics I</td>
</tr>
<tr>
<td>ENGRMAE 230B</td>
<td>Viscous Incompressible Fluid Mechanics II</td>
</tr>
<tr>
<td>ENGRMAE 230C</td>
<td>Compressible Fluid Dynamics</td>
</tr>
<tr>
<td>ENGRMAE 254</td>
<td>Mechanics of Solids and Structures</td>
</tr>
<tr>
<td>ENGRMAE 255</td>
<td>Composite Materials and Structures</td>
</tr>
<tr>
<td>ENGRMAE 258</td>
<td>Mechanical Behavior of Solids - Continuum Theories</td>
</tr>
<tr>
<td>ENGRMSE 205</td>
<td>Materials Physics</td>
</tr>
<tr>
<td>ENGRMSE 254</td>
<td>Polymer Science and Engineering</td>
</tr>
<tr>
<td>ENGRMSE 255A</td>
<td>Design with Ceramic Materials</td>
</tr>
</tbody>
</table>
It should be noted that specific course requirements within the area of emphasis are decided based on consultation with the Director of the MMT concentration.

**Master of Science Degree**

Two options are available for M.S. students: a thesis option and a comprehensive examination option. Both options require the completion of at least 12 courses of study.

**Plan I. Thesis Option**

For the thesis option, students are required to complete an original research project and write an M.S. thesis. A committee of three full-time faculty members is appointed to guide the development of the thesis. Students must also obtain approval for a complete program of study from the program director. At least seven courses (3-unit or 4-unit) must be taken from courses numbered 200–289, among which at least four courses (3-unit or 4-unit) are from MMT core courses and at least three courses (3-unit or 4-unit) are in the area of emphasis approved by the faculty advisor and the graduate advisor. Four units of BME 296, CBEMS 296, EECS 296, ENGR 296, ENGRCEE 296, or ENGRMAE 296 count as the equivalence of one course. Up to three courses equivalent of BME 296, CBEMS 296, EECS 296, ENGR 296, ENGRCEE 296, or ENGRMAE 296 and up to two courses (3-unit or 4-unit) of upper-division undergraduate elective courses taken as a graduate student at UCI can be applied toward the 12-course requirement.

**Plan II. Comprehensive Examination Option**

For the comprehensive examination option, students are required to complete minimally 12 courses (3-unit or 4-unit) of study. At least eight courses (3-unit or 4-unit) must be taken from courses numbered 200–289, among which at least four courses (3-unit or 4-unit) are from MMT core courses and at least four courses (3-unit or 4-unit) are in the area of emphasis approved by the faculty advisor and the graduate advisor. Four units of BME 299, CBEMS 299, EECS 299, ENGRCEE 299, or ENGRMAE 299 count as the equivalence of one course. One course equivalent of BME 299, CBEMS 299, EECS 299, ENGRCEE 299, or ENGRMAE 299 and up to two courses (3-unit or 4-unit) of upper-division undergraduate elective courses taken as a graduate student at UCI can be applied toward the 12-course requirement.

In the last quarter, an oral comprehensive examination on the contents of study will be given by a committee of three faculty members including the advisor and two members appointed by the program director. Part-time study for the M.S. is available and encouraged for engineers working in local industries. Registration for part-time study must be approved in advance by the MMT program director, the School’s Associate Dean, and the Graduate Dean.

In addition to fulfilling the course requirements outlined above, it is a University requirement for the Master of Science degree that students fulfill a minimum of 36 units of study.

**Concurrent Study in the Program in Law and Graduate Studies (PLGS)**

Students have the option to pursue a coordinated curriculum leading to a J.D. degree from the School of Law in conjunction with a Master’s or Ph.D. in Engineering with a concentration in Materials and Manufacturing Technology. For students pursuing the M.S. thesis option, 8 units of research can be substituted for law electives, and comprehensive exam students can petition two course (non-course or area of emphasis courses) to be substituted by law electives.

**Doctor of Philosophy Degree**

The Ph.D. in Engineering with a concentration in Materials and Manufacturing Technology requires a commitment on the part of the student to dedicated study and collaboration with the faculty. Ph.D. students are selected on the basis of outstanding demonstrated potential and scholarship. Applicants must hold the appropriate prerequisite degrees from recognized institutions of high standing. Students entering with a master’s degree may be required to take additional course work, to be decided in consultation with the graduate advisor and the program director. Students without a master’s degree may be admitted into the Ph.D. program. However, these students will be required to complete the degree requirements above for the master’s degree prior to working on doctoral studies. After substantial academic preparation, Ph.D. candidates work under the supervision of faculty advisors. The process involves immersion in a research atmosphere and culminates in the production of original research results presented in a dissertation.

Milestones to be passed in the Ph.D. program include the following: acceptance into a research group by the faculty advisor during the student’s first year of study, successful completion of the Ph.D. preliminary examination during years one or two, development of a research proposal, passing the
qualifying examination during year three (second year for those who entered with a master’s degree), and the successful completion and defense of the dissertation during the fourth or fifth year. There is no foreign language requirement.

The degree is granted upon the recommendation of the doctoral committee and the Dean of Graduate Division. 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.

M.S. in Engineering Management

204 Rockwell Engineering Center; 949-824-8090
http://www.eng.uci.edu/admissions/graduate/programs-and-concentrations/engineering-management

John C. LaRue, Professor of Mechanical and Aerospace Engineering, The Henry Samueli School of Engineering
Gerardo Okhuysen, Equity Advisor & Associate Dean of MBA Programs, The Paul Merage School of Business

Engineering Management Steering Committee

Imran S. Currim: Marketing research, customer choice, design and marketing of products and services, customer behavior online, and assessing the impact of competitive product and service features and marketing efforts on consumer choice and market share

Peter Burke: Fluid mechanics, micro-electrical-mechanical systems (MEMS), turbulence, heat transfer, instrumentation

Fadi J. Kurdahi: VLSI system design, design automation of digital systems

John C. LaRue: Fluid mechanics, micro-electrical-mechanical systems (MEMS), turbulence, heat transfer, instrumentation

Marc J. Madou: Fundamental aspects of micro/nano-electromechanical systems (MEMS/NEMS), biosensors, nanofluidics, biomimetics

Gerardo Okhuysen: Management of task and environmental uncertainty

Jean-Daniel M. Saphores: Transportation economics, planning and policy, environmental and natural resource economics and policy, quantitative methods

The Master of Science in Engineering Management is a graduate degree jointly offered by The Paul Merage School of Business and The Henry Samueli School of Engineering that will prepare engineers for leadership roles in technology, science, government, and engineering-based companies and organizations. The curriculum includes courses in engineering from The Henry Samueli School of Engineering and courses in business administration from The Paul Merage School of Business. Students will emerge as innovators by taking on the role of business and engineering project managers tasked with solving complex engineering product development challenges through consulting projects, business plans, and exposure to current issues within the engineering sector. Through this process, quantitative and qualitative skills along with business communication skills will be developed.

This competitive major teaches business from the engineering perspective and engineering from the business perspective, and students will learn to think about their work through the lens of innovation and to develop a crucial view to enhance their careers.

Admissions

Applicants apply directly to The Samueli School for the M.S. in Engineering Management. Applicants must meet any applicable prerequisite requirements for the specific engineering specialization they wish to pursue. Admission to graduate standing in The Samueli School of Engineering is generally accorded to those possessing at least a B.S. in engineering or an allied field obtained with an acceptable level of scholarship from an institution of recognized standing. Those seeking admission without the prerequisite scholarship record may, in some cases, undertake remedial work; if completed at the stipulated academic level, they will be considered for admission. Those admitted from an allied field may be required to take supplementary upper-division courses in basic engineering subjects.

The Samueli and Merage Schools will evaluate applicants on their prior academic record and their potential for management and leadership as demonstrated in submitted application materials including work experience and in an interview. These materials will include university transcripts, GRE test scores, letters of recommendation, and a Statement of Purpose. Competitive applicants will be interviewed by the Merage School.

Master of Science Degree: Plan II: Comprehensive Exam Option

The M.S. degree requires the completion of designated course work which corresponds to a minimum of 17 courses beyond the bachelor’s degree. As part of the program, students must complete a two-week orientation and an intensive course in early to mid-September preceding the fall quarter which presents fundamental concepts of management to initiate students into the concrete challenges that managers in high-performing organizations typically confront.

Core Requirements

Due to the interdisciplinary nature of this degree, it is important to establish a common foundation in Engineering Management for students from various backgrounds. This foundation is sufficiently covered in Engineering Management courses that are listed below and that deal with the following topics:
Electives

Business. In addition to the core courses listed above, at least five additional courses from The Merage School of Business are required. (Students will be recommended certain classes based on career tracks they plan to pursue.)

- Three Merage School M.B.A. core courses;
- Two additional courses from a selected group of either core or elective courses.

M.B.A. Courses

Core:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>MGMTMBA 201A</td>
<td>Statistics for Management</td>
</tr>
<tr>
<td>MGMTMBA 201B</td>
<td>Management Science</td>
</tr>
<tr>
<td>MGMTMBA 202</td>
<td>Organizational Behavior for Management</td>
</tr>
<tr>
<td>MGMTMBA 203A</td>
<td>Financial Reporting for Management</td>
</tr>
<tr>
<td>MGMTMBA 203B</td>
<td>Driving Profitability Through Management Accounting</td>
</tr>
<tr>
<td>MGMTMBA 204A</td>
<td>Microeconomics for Management</td>
</tr>
<tr>
<td>MGMTMBA 204B</td>
<td>Macroeconomics for Management</td>
</tr>
<tr>
<td>MGMTMBA 205</td>
<td>Marketing Management</td>
</tr>
<tr>
<td>MGMTMBA 206</td>
<td>Business and Government</td>
</tr>
<tr>
<td>MGMTMBA 207</td>
<td>Competing with Digital: Technology, Analytics, Platforms</td>
</tr>
<tr>
<td>MGMTMBA 208</td>
<td>Operations Management</td>
</tr>
<tr>
<td>MGMTMBA 209A</td>
<td>Managerial Finance</td>
</tr>
<tr>
<td>MGMTMBA 210</td>
<td>Strategic Management</td>
</tr>
</tbody>
</table>

Electives:

Refer to the Business School section of the Catalogue for a list of current M.B.A. electives.

Engineering. In addition to the core courses listed above, at least five courses from The Samueli School are required. (Students will be recommended certain classes based on career tracks they plan to pursue.)

- Three courses from a chosen primary specialization in Engineering: Biomedical Engineering, Chemical and Biochemical Engineering, Civil Engineering, Electrical and Computer Engineering, Materials Science and Engineering, or Mechanical and Aerospace Engineering;
- Two additional elective courses chosen from the primary specialization, from another specialization, or from other courses within or outside The Samueli School as approved by the Director or Director-Elect.

Approved Specialization Courses

Biomedical Engineering:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>BME 210</td>
<td>Molecular and Cellular Engineering</td>
</tr>
<tr>
<td>BME 213</td>
<td>Systems Cell and Developmental Biology</td>
</tr>
<tr>
<td>BME 220</td>
<td>Sensory Motor Systems</td>
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<tr>
<td>BME 221</td>
<td>Organ Transport Systems</td>
</tr>
<tr>
<td>BME 230A</td>
<td>Applied Engineering Mathematics I</td>
</tr>
<tr>
<td>BME 230B</td>
<td>Applied Engineering Mathematics II</td>
</tr>
<tr>
<td>BME 233</td>
<td>Dynamic Systems in Biology and Medicine</td>
</tr>
<tr>
<td>BME 251</td>
<td>Engineering Medical Optics</td>
</tr>
<tr>
<td>BME 260</td>
<td>Microfluids and Lab-On-A-Chip</td>
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<tr>
<td>BME 261</td>
<td>Biomedical Microdevices</td>
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<td>Course Code</td>
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<tr>
<td>BME 262</td>
<td>Microimplants</td>
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<tr>
<td><strong>Chemical and Biochemical Engineering:</strong></td>
<td></td>
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<tr>
<td>CBEMS 215</td>
<td>Kinetics of Biochemical Networks</td>
</tr>
<tr>
<td>CBEMS 218</td>
<td>Bioengineering with Recombinant Microorganisms</td>
</tr>
<tr>
<td>CBEMS 219</td>
<td>Biomaterials: Structural Biology and Assembly</td>
</tr>
<tr>
<td>CBEMS 221</td>
<td>Drug Delivery</td>
</tr>
<tr>
<td>CBEMS 228</td>
<td>Colloid Science and Engineering</td>
</tr>
<tr>
<td>CBEMS 233</td>
<td>Nuclear and Radiochemistry</td>
</tr>
<tr>
<td>CBEMS 241</td>
<td>Nano-Scale Materials and Applications</td>
</tr>
<tr>
<td>CBEMS 243</td>
<td>Chemistry and Technology for the Nuclear Fuel Cycle</td>
</tr>
<tr>
<td>CBEMS 249</td>
<td>Special Topics in Chemical Engineering and Materials Science</td>
</tr>
<tr>
<td>CBEMS 280</td>
<td>Optoelectronics Packaging</td>
</tr>
<tr>
<td><strong>Civil Engineering:</strong></td>
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<tr>
<td>ENGRCEE 220A</td>
<td>Travel Demand Analysis I</td>
</tr>
<tr>
<td>ENGRCEE 221A</td>
<td>Transportation Systems Analysis I</td>
</tr>
<tr>
<td>ENGRCEE 225B</td>
<td>Transportation Planning Models II</td>
</tr>
<tr>
<td>ENGRCEE 229A</td>
<td>Traffic Systems Operations and Control I</td>
</tr>
<tr>
<td>ENGRCEE 249</td>
<td>Earthquake Engineering</td>
</tr>
<tr>
<td>ENGRCEE 250</td>
<td>Finite Element Method in Structural Engineering</td>
</tr>
<tr>
<td>ENGRCEE 258</td>
<td>Earthquake Resistant Structural Design</td>
</tr>
<tr>
<td>ENGRCEE 262</td>
<td>Environmental Chemistry II</td>
</tr>
<tr>
<td>ENGRCEE 263</td>
<td>Advanced Biological Treatment Processes</td>
</tr>
<tr>
<td>ENGRCEE 264</td>
<td>Carbon and Energy Footprint Analysis</td>
</tr>
<tr>
<td>ENGRCEE 265</td>
<td>Physical-Chemical Treatment Processes</td>
</tr>
<tr>
<td>ENGRCEE 266</td>
<td>Drinking Water and Wastewater Biotechnology</td>
</tr>
<tr>
<td>ENGRCEE 272</td>
<td>Groundwater Hydrology</td>
</tr>
<tr>
<td>ENGRCEE 273</td>
<td>Watershed Modeling</td>
</tr>
<tr>
<td>ENGRCEE 276</td>
<td>Hydrology</td>
</tr>
<tr>
<td>ENGRCEE 281</td>
<td>Structural Reliability</td>
</tr>
<tr>
<td><strong>Electrical and Computer Engineering:</strong></td>
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</tr>
<tr>
<td>EECS 202A</td>
<td>Principles of Imaging</td>
</tr>
<tr>
<td>EECS 203A</td>
<td>Digital Image Processing</td>
</tr>
<tr>
<td>EECS 211</td>
<td>Advanced System Software</td>
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<tr>
<td>EECS 213</td>
<td>Computer Architecture</td>
</tr>
<tr>
<td>EECS 215</td>
<td>Design and Analysis of Algorithms</td>
</tr>
<tr>
<td>EECS 217</td>
<td>VLSI System Design</td>
</tr>
<tr>
<td>EECS 219</td>
<td>Distributed Software Architecture and Design</td>
</tr>
<tr>
<td>EECS 221</td>
<td>Topics in Computer Engineering</td>
</tr>
<tr>
<td>EECS 222</td>
<td>Embedded System Modeling</td>
</tr>
<tr>
<td>EECS 225</td>
<td>Embedded Systems Design</td>
</tr>
<tr>
<td>EECS 230</td>
<td>Energy Efficiency</td>
</tr>
<tr>
<td>EECS 241A</td>
<td>Digital Communications I</td>
</tr>
<tr>
<td>EECS 248A</td>
<td>Computer and Communication Networks</td>
</tr>
<tr>
<td>EECS 250</td>
<td>Digital Signal Processing I</td>
</tr>
<tr>
<td>EECS 261A</td>
<td>Linear Optimization Methods</td>
</tr>
<tr>
<td>EECS 267A</td>
<td>Industrial and Power Electronics</td>
</tr>
<tr>
<td>EECS 277C</td>
<td>Nanotechnology</td>
</tr>
<tr>
<td>EECS 278</td>
<td>Micro-System Design</td>
</tr>
<tr>
<td>EECS 279</td>
<td>Micro-Sensors and Actuators</td>
</tr>
<tr>
<td><strong>Materials Science and Engineering:</strong></td>
<td></td>
</tr>
<tr>
<td>CBEMS 221</td>
<td>Drug Delivery</td>
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<tr>
<td>CBEMS 241</td>
<td>Nano-Scale Materials and Applications</td>
</tr>
</tbody>
</table>
The M.S. in Biotechnology Management

The M.S. in Biotechnology Management is a joint graduate degree that will prepare scientists for leadership roles in biotechnology, science, and engineering-based companies through a curriculum comprised of courses from the Department of Molecular Biology and Biochemistry (MB&B) in the School of Biological Sciences, the Department of Biomedical Engineering in The Henry Samueli School of Engineering, and The Paul Merage School of Business. Students will receive advanced training in biotechnology through course work, a teaching laboratory, and two quarters of independent research in a faculty laboratory of their choosing. They will also learn to think as a business manager by solving product development challenges through consulting projects, creating business plans, and by exposure to current issues within the biotechnology sector. Students will develop quantitative and qualitative skills along with business communication skills. Students will learn about business from the biotechnology perspective and biotechnology from the business perspective, and will be taught to think about their work through the lens of innovation, a crucial view for their careers.

Complete program information is available in the School of Biological Sciences section of the Catalogue.

Biomedical Engineering Courses

**BME 1. Introduction to Biomedical Engineering. 3 Units.**

Introduction to the central topics of biomedical engineering. Offers a perspective on bioengineering as a discipline in a seminar format. Principles of problem definition, team design, engineering inventiveness, information access, communication, ethics, and social responsibility are emphasized.

(Design units: 1)

Restriction: Biomedical Engineering Majors have first consideration for enrollment. Biomedical Engr: Premedical Majors have first consideration for enrollment.

**BME 50A. Cell and Molecular Engineering. 4 Units.**

Physiological function from a cellular, molecular, and biophysical perspective. Applications to bioengineering design.

(Design units: 2)

Corequisite: BME 1

Prerequisite: CHEM 1C

Restriction: Biomedical Engineering Majors have first consideration for enrollment. Chemical Engineering Majors have first consideration for enrollment. Materials Science Engineering Majors have first consideration for enrollment.
BME 50B. Cell and Molecular Engineering. 4 Units.
Physiological function from a cellular, molecular, and biophysical perspective. Applications to bioengineering design.

(Design units: 2)

Prerequisite: BME 50A and PHYSICS 7D

Restriction: Biomedical Engineering Majors have first consideration for enrollment. Biomedical Engr: Premedical Majors have first consideration for enrollment.

BME 60A. Engineering Analysis/Design: Data Acquisition. 4 Units.
Fundamentals of LabVIEW programming, basics of computer-based experimentation, establishing interface between computer and data acquisition instrumentation, signal conditioning basics. Materials fee.

(Design units: 2)

Corequisite: BME 1
Prerequisite: PHYSICS 7D

Restriction: Biomedical Engineering Majors have first consideration for enrollment. Biomedical Engr: Premedical Majors have first consideration for enrollment.

BME 60B. Engineering Analysis/Design: Data Analysis. 4 Units.
Overview of MATLAB; numeric, cell, and structure arrays; file management; plotting and model building; solving linear algebraic equations; differential equations; symbolic process. Materials fee.

(Design units: 1)

Prerequisite: BME 60A and MATH 3A

Overlaps with ENGRCEE 20.

Restriction: Biomedical Engineering Majors have first consideration for enrollment. Biomedical Engr: Premedical Majors have first consideration for enrollment.

BME 60C. Engineering Analysis/Design: Computer-Aided Design. 4 Units.
Introduction to SolidWorks and Computer-Aided Design software; design; analysis; rapid prototyping; visualization and presentation; planning and manufacturing. Materials fee.

(Design units: 2)

Prerequisite: BME 60B

Restriction: Biomedical Engineering Majors have first consideration for enrollment. Biomedical Engr: Premedical Majors have first consideration for enrollment.

BME 110A. Biomechanics I. 4 Units.
Introduction to statics. Rigid bodies, analysis of structures, forces in beams, moments of inertia.

(Design units: 1)

Prerequisite: PHYSICS 7D and PHYSICS 7LD and PHYSICS 7E and MATH 3A and MATH 3D

Restriction: Biomedical Engineering Majors have first consideration for enrollment. Biomedical Engr: Premedical Majors have first consideration for enrollment. Materials Science Engineering Majors have first consideration for enrollment.

BME 110B. Biomechanics II. 4 Units.
Introduction to dynamics. Kinematics of Particles, Newton's Second Law, System's of Particles, Kinematics of Rigid Bodies, Motion in three dimensions.

(Design units: 1)

Prerequisite: BME 110A

Restriction: Biomedical Engineering Majors have first consideration for enrollment. Biomedical Engr: Premedical Majors have first consideration for enrollment. Materials Science Engineering Majors have first consideration for enrollment.
BME 110C. Biomechanics III. 4 Units.
Applications of statics and dynamics to biomedical systems. Cellular biomechanics, hemodynamics, circulatory system, respiratory system, muscles and movement, skeletal biomechanics. Applications to bioengineering design.

(Design units: 1)
Prerequisite: BME 110B
Restriction: Biomedical Engineering Majors have first consideration for enrollment.

BME 111. Design of Biomaterials. 4 Units.

(Design units: 3)
Corequisite: BME 50B or BIO SCI 99.
Restriction: Biomedical Engineering Majors have first consideration for enrollment. Biomedical Engr: Premedical Majors have first consideration for enrollment. Materials Science Engineering Majors have first consideration for enrollment.

BME 114. Genetic Engineering and Synthetic Biology. 4 Units.
Exploring how biological function can be engineered and “synthesized” from the DNA level up.

(Design units: 0)
Prerequisite: CHEM 1C and MATH 3D and BME 50A and BME 50B
Restriction: Biomedical Engineering Majors have first consideration for enrollment.

BME 120. Sensory Motor Systems. 4 Units.
A quantitative and systems approach to understanding physiological systems. Systems covered include the nervous and musculoskeletal systems.

(Design units: 2)
Prerequisite: (BME 60B or EECS 10 or EECS 12 or ENGRCEE 20 or ENGRMAE 10) and MATH 3D and PHYSICS 7D
Restriction: Biomedical Engineering Majors have first consideration for enrollment. Biomedical Engr: Premedical Majors have first consideration for enrollment. Materials Science Engineering Majors have first consideration for enrollment.
Concurrent with BME 220.

BME 121. Quantitative Physiology: Organ Transport Systems. 4 Units.
A quantitative and systems approach to understanding physiological systems. Systems covered include the cardiopulmonary, circulatory, and renal systems.

(Design units: 1)
Prerequisite: (BME 60B or EECS 10 or EECS 12 or ENGRCEE 20 or ENGRMAE 10) and MATH 3A and MATH 3D
Restriction: Biomedical Engineering Majors have first consideration for enrollment. Biomedical Engr: Premedical Majors have first consideration for enrollment. Chemical Engineering Majors have first consideration for enrollment.

BME 130. Biomedical Signals and Systems. 4 Units.
Analysis of analog and digital biomedical signals; Fourier Series expansions; difference and differential equations; convolutions. System models: discrete-time and continuous-time linear time-invariant systems; Laplace and Fourier transforms. Analysis of signals and systems using computer programs.

(Design units: 1)
Corequisite: BME 60B
Prerequisite: MATH 3A and MATH 3D. Recommended: STATS 8.
Restriction: Biomedical Engineering Majors have first consideration for enrollment. Biomedical Engr: Premedical Majors have first consideration for enrollment.
BME 132. Introduction to Computational Biology. 4 Units.

Prerequisite: MATH 2D or MATH 3A or STATS 7 or STATS 8

Same as BIO SCI M123, COMPSCI 183.
Concurrent with MOL BIO 223 and BME 232.

BME 135. Photomedicine. 4 Units.
Studies the use of optical and engineering-based systems (laser-based) for diagnosis, treating diseases, manipulation of cells and cell function. Physical, optical, and electro-optical principles are explored regarding molecular, cellular, organ, and organism applications.

(Design units: 0)

Prerequisite: PHYSICS 3C or PHYSICS 7D

Same as BIO SCI D130.
Restriction: Biomedical Engineering Majors have first consideration for enrollment.

BME 136. Engineering Medical Optics. 4 Units.
Principles of optics and photonics, integration of optical components into systems and devices, and analysis of physiological signals obtained from Biophotonics measurements.

(Design units: 3)

Prerequisite: BME 130 and BME 135
Restriction: Biomedical Engineering Majors have first consideration for enrollment.
Concurrent with BME 251.

BME 137. Introduction to Biomedical Imaging. 4 Units.
Introduction to imaging modalities widely used in medicine and biology, including X-ray, computed tomography (CT), nuclear medicine (PET and SPET), ultrasonic imaging, magnetic resonance imaging (MRI), optical tomography, imaging contrast, imaging processing, and complementary nature of the imaging modalities.

(Design units: 1)

Prerequisite: BME 130 or EECS 50 or EECS 150
Restriction: Biomedical Engineering Majors have first consideration for enrollment.

BME 138. Spectroscopy and Imaging of Biological Systems. 4 Units.
Principles of spectroscopy; absorption; molecular orbitals; multiphoton transitions; Jablonski diagram; fluorescence anisotropy; fluorescence decay; quenching; FRET; excited state reactions; solvent relaxations; instruments; microscopy: wide field, LSM, TPE; fluorescent probes, fluctuations spectroscopy; optical resolution and super-resolution; CARS and SHG microscopy.

(Design units: 1)

Prerequisite: MATH 3A and MATH 3D. Recommended: STATS 8.
Restriction: Biomedical Engineering Majors only. Biomedical Engr: Premedical Majors only.
Concurrent with BME 238.

BME 140. Design of Biomedical Electronics. 4 Units.
Analog and digital circuits in bioinstrumentation. AC and DC circuit analysis, design and construction of filter and amplifiers using operational amplifier, digitization of signal and data acquisition, bioelectrical signal, design and construction of ECG instrument, bioelectrical signal measurement and analysis. Materials fee.

(Design units: 3)

Prerequisite: BME 60C and BME 130
Restriction: Biomedical Engineering Majors have first consideration for enrollment.
BME 147. Microfluidics and Lab-on-a-Chip. 4 Units.
Introduction to principles of microfluidics and state-of-the-art micro Total Analysis Systems (uTAS). Lab-on-a-Chip for bimolecular assays with device design principles for microscale sample preparation, flow transport, bimolecular manipulation, separation and detection, and the technologies for integrating these devices into microsystems.

(Design units: 1)
Prerequisite: BME 110C
Restriction: Biomedical Engineering Majors have first consideration for enrollment.
Concurrent with BME 260.

BME 148. Microimplants. 4 Units.
Essential concepts of biomedical implants at the micro scale. Design, fabrication, and applications of several microimplantable devices including cochlear, retinal, neural, and muscular implants.

(Design units: 1)
Prerequisite: BME 111
Restriction: Biomedical Engineering Majors have first consideration for enrollment.
Concurrent with BME 262.

BME 149. Biomedical Microdevices . 4 Units.
In-depth review of microfabricated devices designed for biological and medical applications. Studies of the design, implementation, manufacturing, and marketing of commercial and research bio-medical devices.

(Design units: 0)
Concurrent with BME 261.

BME 150. Biotransport Phenomena. 4 Units.
Fundamentals of heat and mass transfer, similarities in the respective rate equations. Emphasis on practical application of fundamental principles.

(Design units: 1)
Prerequisite: BME 60B and MATH 3A and MATH 3D
Overlaps with CBEMS 125C.
Restriction: Biomedical Engineering Majors have first consideration for enrollment. Biomedical Engr: Premedical Majors have first consideration for enrollment.

BME 160. Tissue Engineering. 4 Units.
Quantitative analysis of cell and tissue functions. Emerging developments in stem cell technology, biodegradable scaffolds, growth factors, and others important in developing clinical products. Applications of bioengineering.

(Design units: 2)
Prerequisite: (BME 50B or BIO SCI 99) and BME 111 and BME 121 and BME 150
Restriction: Biomedical Engineering Majors have first consideration for enrollment. Biomedical Engr: Premedical Majors have first consideration for enrollment.

BME 170. Biomedical Engineering Laboratory. 4 Units.
Measurement and analysis of biological systems using engineering tools and techniques. Laboratory experiments involve living systems with the emphasis on measuring physiological parameters. Labs: Introduction to Electroencephalography, Fiberoptic thermometry, Neurorehabilitation Engineering. Spectroscopy principles of the common pulse oximeter. Materials fee.

(Design units: 1)
Prerequisite: BME 111 and BME 120 and BME 121 and BME 130 and BME 140
Restriction: Biomedical Engineering Majors have first consideration for enrollment.
BME 171. Cell and Tissue Engineering Laboratory. 4 Units.
Techniques in molecular, cellular, and tissue engineering. Topics include bacterial and mammalian cell culture, DNA cloning and gene transfer, fabrication of biomaterial scaffolds, and immunassays and microscopy techniques for cell-based assays.

(Design units: 0)

Prerequisite: BME 160

Restriction: Biomedical Engineering Majors have first consideration for enrollment. Biomedical Engr: Premedical Majors have first consideration for enrollment.

BME 180A. Biomedical Engineering Design. 3 Units.
Design strategies, techniques, tools, and protocols commonly encountered in biomedical engineering; clinical experience at the UCI Medical Center and Beckman Laser Institute; industrial design experience in group projects with local biomedical companies; ethics, economic analysis, and FDA product approval. Materials fee.

(Design units: 3)

Prerequisite: BME 60C and BME 110C and BME 111 and BME 120 and BME 121 and BME 140. BME 180A, BME 180B, and BME 180C must be taken in the same academic year.

Grading Option: In progress only.

Restriction: Seniors only. Biomedical Engineering Majors only.

BME 180B. Biomedical Engineering Design. 3 Units.
Design strategies, techniques, tools, and protocols commonly encountered in biomedical engineering; clinical experience at the UCI Medical Center and Beckman Laser Institute; industrial design experience in group projects with local biomedical companies; ethics, economic analysis, and FDA product approval. Materials fee.

(Design units: 3)

Prerequisite: BME 180A. BME 180A, BME 180B, and BME 180C must be taken in the same academic year.

Grading Option: In progress only.

Restriction: Seniors only. Biomedical Engineering Majors only.

BME 180C. Biomedical Engineering Design. 3 Units.
Design strategies, techniques, tools, and protocols commonly encountered in biomedical engineering; clinical experience at the UCI Medical Center and Beckman Laser Institute; industrial design experience in group projects with local biomedical companies; ethics, economic analysis, marketing, and FDA product approval. Materials fee.

(Design units: 3)

Prerequisite: BME 180B. BME 180A, BME 180B, and BME 180C must be taken in the same academic year.

Restriction: Seniors only. Biomedical Engineering Majors only.

BME 195. Special Topics in Biomedical Engineering. 1-4 Units.
Studies in selected areas of Biomedical Engineering. Topics addressed vary each quarter.

(Design units: 1-4)

Prerequisite: Prerequisites vary.

Repeatability: Unlimited as topics vary.

BME 197. Seminars in Biomedical Engineering. 2 Units.
Presentation of advanced topics and reports of current research efforts in Biomedical Engineering.

(Design units: 1-2)

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

Concurrent with BME 298.
BME 199. Individual Study. 1-4 Units.
Independent research conducted in the lab of a biomedical engineering core faculty member. A formal written report of the research conducted is required at the conclusion of the quarter.

(Design units: 1-4)

Prerequisite: BIO SCI 194S

Repeatability: May be taken for credit for 8 units.

BME 199P. Individual Study. 1-4 Units.
Supervised independent reading, research, or design for undergraduate Engineering majors. 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)

Grading Option: Pass/no pass only.

Repeatability: May be repeated for credit unlimited times.

BME 210. Molecular and Cellular Engineering. 4 Units.
Engineering of physiological function at the genetic, cellular, and tissue scales. Topics include cloning and genetic engineering, extracellular matrix biomaterials, principles of regenerative medicine and tissue engineering, and experimental design.

Restriction: Graduate students only.

BME 211. Microscale Tissue Engineering. 4 Units.
Engineering of physiological function at the scale of individual cells. Topics include cell micropatterning, microfluidic tissue culture, engineering the cellular microenvironment, and microphysiological systems.

Restriction: Graduate students only.

BME 212. Cardiovascular Mechanobiology. 4 Units.
Advanced topics in cellular engineering and mechanobiology, with focus on the cardiovascular system. Tools and techniques used to manipulate and measure mechanical forces at the molecular, cellular, tissue, and organ levels, and their applications in cardiovascular devices and tissue engineering.

Restriction: Graduate students only.

BME 213. Systems Cell and Developmental Biology. 4 Units.
Introduces concepts needed to understand cell and developmental biology at the systems level, i.e., how the parts (molecules) work together to create a complex output. Emphasis on using mathematical/computational modeling to expand/modify insights provided by intuition.

Same as DEV BIO 232.

Restriction: Graduate students only.

BME 215. Linking Modeling and Experiments in Bioengineering. 4 Units.
Overview of modeling based on experimental techniques in bioengineering. Construct and evaluate models of varying complexity and to relate them to experimental data.

Prerequisite: BME 220 and BME 221

Restriction: Graduate students only.

BME 218. Directed Evolution. 4 Units.
Directed evolution harnesses the processes of Darwinian evolution for biomolecular engineering goals. This class will begin with fundamental principles in evolutionary biology and move on to the experimental evolution techniques and their applications.

Restriction: Graduate students only.

BME 220. Sensory Motor Systems. 4 Units.
A quantitative and systems approach to understanding physiological systems. Systems covered include the nervous and musculoskeletal systems.

Restriction: Graduate students only.

Concurrent with BME 120.
BME 221. Organ Transport Systems. 4 Units.
A quantitative and systems approach to understanding physiological systems. Systems covered include the cardiopulmonary, circulatory, and renal systems.

Restriction: Graduate students only.

BME 222. Biofluid Mechanics. 4 Units.
Introduces principles of biofluid mechanics in a research oriented scheme and approaches a wide spectrum of biofluid related problems in human body and solutions that involves engineering concepts.

Restriction: Graduate students only.

BME 223. Critical Thinking in Cardiovascular Research. 2 Units.
Interpretation and critical assessment of current cardiovascular research in basic science, application of engineering tools, and clinical cardiology and cardiovascular surgery. Open only to graduate students engaged in research.

Restriction: Graduate students only.

BME 224. Molecular and Cellular Biophotonics. 4 Units.
Principles underlying the application of photonic technologies to biomolecular and cellular systems. Sample technologies Optical Tweezers, Linear and Nonlinear Optical Microscopy and Fluorescence Lifetime and Correlation Methods, and their use to investigate emergent problems in Molecular, Cellular, and Developmental Biology.

Same as CHEM 224.

Restriction: Graduate students only.

BME 225. Tissue and Organ Biophotonics. 4 Units.
Principles underlying the application of photonic technologies to tissues, organs, organisms. Sample technologies include Optical Coherence Tomography, Optical Speckle Imaging, Optoacoustic Imaging, Wide-Field Spectroscopic Imaging, Diffuse Optical Spectroscopy. Addressing the use of these technologies to detect/monitor disease and physiological processes.

BME 230A. Applied Engineering Mathematics I. 4 Units.
Analytical techniques applied to engineering problems in transport phenomena, process dynamics and control, and thermodynamics.

BME 230B. Applied Engineering Mathematics II. 4 Units.
Focuses on biomedical system identification. Includes fundamental techniques of model building and testing such as formulation, solution of governing equations, sensitivity theory, identifiability theory, and uncertainty analysis.

Restriction: Graduate students only.

BME 232. Introduction to Computational Biology. 4 Units.

Same as MOL BIO 223.

Restriction: Graduate students only.

Concurrent with BIO SCI M123 and COMPSCI 183 and BME 132.

BME 233. Dynamic Systems in Biology and Medicine. 4 Units.
Introduces principles of system theory to analyze biological, biochemical, physiological, and bioengineering systems. Analytical and computational tools are used to model and analyze dynamic systems such as population, neuronal and heart dynamics, biochemical and physiological systems, oxygen diffusion and similar.

Restriction: Graduate students only.

BME 234. Neuroimaging Data Analysis. 4 Units.
Knowledge and understanding of recent techniques for the analysis of healthy and pathological structure and function in neuroimaging data.

Restriction: Graduate students only.
BME 238. Spectroscopy and Imaging of Biological Systems. 4 Units.
Principles of spectroscopy; absorption; molecular orbitals; multiphoton transitions; Jablonski diagram; fluorescence anisotropy; fluorescence decay; quenching; FRET; excited state reactions; solvent relaxations; instruments; microscopy: wide field, LSM, TPE; fluorescent probes, fluctuations spectroscopy; optical resolution and super-resolution; CARS and SHG microscopy.

Restriction: Graduate students only.
Concurrent with BME 138.

BME 240. Introduction to Clinical Medicine for Biomedical Engineering. 4 Units.
An introduction to clinical medicine for graduate students in biomedical engineering. Lectures and rotations through nephology, gastroenterology, pulmonary, and critical care cardiology.

Restriction: Graduate students only. Biomedical Engineering Majors only.

BME 250. Biospectroscopy. 4 Units.
Principles of optical spectroscopy for biomedical engineering. Will focus on optical spectroscopy of biological relevant molecules, spectroscopy in cells and tissue. Spectroscopy techniques based on fluorescence.

Restriction: Graduate students only.

BME 251. Engineering Medical Optics. 4 Units.
Principles of optics and photonics, integration of optical components into systems and devices, and analysis of physiologic signals obtained from Biophotonics measurements.

Restriction: Graduate students only.

BME 252. Critical Thinking in Biophotonics. 2 Units.
Critical thematic review of current research papers in the field of Biophotonics.

Repeatability: May be taken for credit 2 times.

Restriction: Graduate students only.

BME 260. Microfluids and Lab-On-A-Chip. 4 Units.
Introduction to microfluidics and state-of-the-art micro Total Analysis Systems (uTAS). Lab-on-a-Chip for biomolecular assays with device design principles for microscale sample preparation, flow transport, biomolecular manipulation, separation and detection, and the technologies for integrating these devices into microsystems.

Restriction: Graduate students only.

Concurrent with BME 147.

BME 261. Biomedical Microdevices. 4 Units.
In-depth review of microfabricated devices designed for biological and medical applications. Studies of the design, implementation, manufacturing, and marketing of commercial and research bio-medical devices.

Restriction: Graduate students only.

Concurrent with BME 149.

BME 262. Microimplants. 4 Units.
Essential concepts of biomedical implants at the micro scale. Design, fabrication, and applications of several microimplantable devices including cochlear, retinal, neural, and muscular implants.

Restriction: Graduate students only.

Concurrent with BME 148.

BME 263. Nanomedicine. 4 Units.
Covers the use of inorganic nanocrystals and nanocarriers for molecular detection of human disease and targeted drug delivery. Techniques for synthesis and bioconjugation, molecular targeting, adhesion dynamics, and unique physical properties of nanomaterials.

Restriction: Graduate students only.
BME 264. Auditory Science and Technology. 2 Units.
Advanced topics in auditory science and technology from cochlear mechanics to cochlear implants.

Repeatability: May be repeated for credit unlimited times.

Restriction: Graduate students only.

BME 290. Critical Thinking and Writing. 4 Units.
Critical thinking and writing are essential ingredients for success in scientific research. Examines examples from the scientific literature to extract principles of good scientific reasoning, experimental design, and writing.

Restriction: Graduate students only.

BME 295. Special Topics in Biomedical Engineering. 1-4 Units.
Studies in selected areas of Biomedical Engineering. Topics addressed vary each quarter.

Prerequisite: Prerequisites vary.

Repeatability: Unlimited as topics vary.

BME 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.

Restriction: Graduate students only.

BME 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.

BME 298. Seminars in Biomedical Engineering. 2 Units.
Presentation of advanced topics and reports of current research efforts in biomedical engineering. Designed for graduate students in the Biomedical Engineering program.

Grading Option: Satisfactory/unsatisfactory only.

Repeatability: May be repeated for credit unlimited times.

Concurrent with BME 197.

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

Repeatability: May be repeated for credit unlimited times.

Chem Engr and Materials Sci Courses

Principles and concepts underlying the study of advanced materials including alloys, composites, ceramics, semiconductors, polymers, ferroelectrics, and magnetics. Crystal structure and defects, surface and interface properties, thermodynamics and kinetics of phase transformations, and material processing, related to fundamental material properties.

Restriction: Graduate students only.

ENGRMSE 205. Materials Physics. 4 Units.
Covers the electronic, optical, and dielectric properties of crystalline materials to provide a foundation of the underlying physical principles of governing the properties of existing and emerging electronic and photonic materials.

Restriction: Graduate students only.
ENGRMSE 254. Polymer Science and Engineering. 4 Units.
An introduction to physical aspects of polymers, including configuration and conformation of polymer chains and characterization techniques; crystallinity viscoelasticity, rheology and processing.
Restriction: Graduate students only.
Concurrent with CBEMS 154.

ENGRMSE 255A. Design with Ceramic Materials. 4 Units.
Prerequisite: ENGR 54
Restriction: Graduate students only.

ENGRMSE 256A. Mechanical Behavior of Engineering Materials. 4 Units.
Principles governing structure and mechanical behavior of materials, relationship relating microstructure and mechanical response with application to elasticity, plasticity, creep, and fatigue, study of rate-controlling mechanisms and failure modes, fracture of materials.
Restriction: Graduate students only.

ENGRMSE 259. Transmission Electron Microscopy. 4 Units.
The theory and operation of the transmission electron microscope (TEM), including the basic construction, electron optics, electron diffraction and reciprocal space, formation of image and electron diffraction information, microanalysis, and specimen preparation.
Prerequisite: ENGRMSE 200
Restriction: Graduate students only.

ENGRMSE 261. High Temperature Deformation of Engineering Materials. 4 Units.
Theoretical and practical aspects of creep and superplasticity in metallic and non-metallic systems are presented. Topics include: creep testing methods, diffusional creep, deformation mechanism maps, and superplasticity in non-metallics.
Restriction: Graduate students only.

ENGRMSE 264. Scanning Electron Microscopy. 4 Units.
The theory and operation of the scanning electron microscope (SEM) and X-ray microanalysis. Topics covered include the basic design and electron optics, electron beam - specimen interactions, image formation and interpretation, X-ray spectrometry, and other related topics and techniques.
Prerequisite: ENGRMSE 200
Restriction: Graduate students only.

ENGRMSE 265. Phase Transformations. 4 Units.
Advanced thermodynamics and kinetics of phase transformations and phase transitions.
Prerequisite: CBEMS 240
Restriction: Graduate students only.

ENGRMSE 273. Electroceramics & Solid State Electrochemical Systems. 4 Units.
Theory, underlying principles, experimental techniques, and applications of electroceramics and solid-state electrochemical systems. Links solid state physics, atomic structure, thermodynamics, defect chemistry, and transport processes to electrical properties of ceramics - spanning from insulators to fast-ion conductors and HT superconductors.
Prerequisite: ENGRMSE 200
Chemical Engr and Materials Sci Courses

**CBEMS 45A. Chemical Processing and Materials Balances. 4 Units.**
Introduction to chemical engineering and the industries where chemical engineers play vital roles. Problem-solving skills and techniques. Quantitative calculations and applications using mass and energy balances. Stoichiometric equations, multiple bypasses, and others in process industries.

(Design units: 0)
Prerequisite: MATH 2B and CHEM 1B and PHYSICS 7C
Restriction: Chemical Engineering Majors have first consideration for enrollment. Environmental Engineering Majors have first consideration for enrollment.

**CBEMS 45B. Chemical Processing and Energy Balances. 3 Units.**
Principles of thermodynamics: definitions, basic concepts, and laws; property relationships; construction of thermodynamic charts and tables; energy balances; phase and chemical equilibria; combined mass and energy balances.

(Design units: 0)
Prerequisite: (CBEMS 45A or PHYSICS 7E) and MATH 3A. CBEMS 45A with a grade of C- or better
Overlaps with ENGRMAE 91, CBEMS 65A.
Restriction: Chemical Engineering Majors have first consideration for enrollment. Materials Science Engineering Majors have first consideration for enrollment.

**CBEMS 45C. Chemical Engineering Thermodynamics. 4 Units.**
Elements of chemical engineering thermodynamics, including equilibrium and stability; equations of state; generalized correlations of properties of materials; properties of ideal and non-ideal mixtures; thermodynamics of real solutions; ideal and non-ideal phase equilibria; chemical equilibria for ideal and non-ideal solutions.

(Design units: 1)
Prerequisite: (EECS 10 or ENGRMAE 10) and MATH 2D and CBEMS 45B. CBEMS 45B with a grade of C- or better
Overlaps with ENGRMAE 115, CBEMS 65B.
Restriction: Chemical Engineering Majors have first consideration for enrollment. Materials Science Engineering Majors have first consideration for enrollment.

**CBEMS 50L. Principles of Materials Science and Engineering. 2 Units.**
Introduction to the experimental techniques to characterize the properties of engineering materials. Emphasis on understanding the influence of microstructure on elastic, plastic, and fracture behavior. Topics include microstructure characterization, heat treatment, grain size effect, precipitation hardening, and impact loading. Materials fee.

(Design units: 0)
Corequisite: ENGR 54
Restriction: Materials Science Engineering Majors have first consideration for enrollment.

**CBEMS 65A. Thermodynamics of Materials. 4 Units.**
Treatment of the laws of thermodynamics and their application in understanding properties and equilibrium states of engineering materials. Develops relationships pertaining to multiphase equilibrium and presents graphical constructions for interpretation of phase diagrams. Statistical thermodynamics in relation to materials phenomena.

(Design units: 0)
Prerequisite: (ENGR 1A or CHEM 1A) and PHYSICS 7C
Overlaps with CBEMS 45B, ENGRMAE 91.
Restriction: Materials Science Engineering Majors have first consideration for enrollment.
CBEMS 65B. Diffusion in Materials. 4 Units.

(Design units: 0)

Prerequisite: CBEMS 65A. CBEMS 65A with a grade of C- or better

Overlaps with CBEMS 45C, ENGRMAE 115.

Restriction: Materials Science Engineering Majors have first consideration for enrollment.

CBEMS 110. Reaction Kinetics and Reactor Design. 4 Units.
Introduction to quantitative analysis of chemical reactions and chemical reactor design. Reactor operations including batch, continuous stirred tank, and tubular reactor. Homogeneous and heterogeneous reactions.

(Design units: 2)

Prerequisite: CHEM 1C and MATH 3D and CBEMS 45B and CBEMS 45C. CBEMS 45B with a grade of C- or better. CBEMS 45C with a grade of C- or better

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

CBEMS 112. Introduction to Biochemical Engineering. 3 Units.
Application of engineering principles to biochemical processes. Topics include microbial pathways, energetics and control systems, enzyme and microbial kinetics and the design and analysis of biological reactors.

(Design units: 1)

Prerequisite: CBEMS 110 and CHEM 1C and MATH 3D

Restriction: Chemical Engineering Majors have first consideration for enrollment.

CBEMS 115. Kinetics of Biochemical Networks. 4 Units.
Principles from statistical mechanics, thermodynamics, and chemical kinetics applied to biochemical systems, from fundamental processes such as receptor-ligand binding and enzyme catalysis, to complex cellular functions including signal transduction and gene regulation.

(Design units: 0)

Restriction: Upper-division students only.

Concurrent with CBEMS 215.

CBEMS 119. Biomaterials: Structural Biology and Assembly. 4 Units.
Application of fundamental concepts in structural biology (proteins, DNA/RNA, carbohydrates, lipids), biomolecular thermodynamics, and molecular interactions to the design of novel biomaterials via self-assembly.

(Design units: 0)

Prerequisite: CBEMS 45C and CBEMS 110

Restriction: Chemical Engineering Majors have first consideration for enrollment. Materials Science Engineering Majors have first consideration for enrollment.

Concurrent with CBEMS 219.
CBEMS 125A. Momentum Transfer. 4 Units.
Fluid statics, surface tension, Newton’s law of viscosity, non-Newtonian and complex flows, momentum equations, laminar and turbulent flow, velocity profiles, flow in pipes and around objects, piping systems design, pumps and mixing, and other applications to chemical and related industries.

(Design units: 0)
Prerequisite: (CBEMS 45C or CBEMS 65B) and MATH 3D. CBEMS 45C with a grade of C- or better. CBEMS 65B with a grade of C- or better
Overlaps with ENGRMAE 130A, ENGRCEE 170.
Restriction: Chemical Engineering Majors have first consideration for enrollment. Materials Science Engineering Majors have first consideration for enrollment.

CBEMS 125B. Heat Transfer. 3 Units.
Principles of conduction, radiation, and convection of heat; phenomenological rate laws, differential and macroscopic energy balances; heat transfer rates, steady state and unsteady state conduction, convection; applications to chemical and related industries.

(Design units: 1)
Prerequisite: CBEMS 125A. CBEMS 125A with a grade of C- or better
Overlaps with CBEMS 125B, ENGRMAE 120.
Restriction: Chemical Engineering Majors have first consideration for enrollment. Materials Science Engineering Majors have first consideration for enrollment.

CBEMS 125C. Mass Transfer. 3 Units.
Molecular and continuum approaches to diffusion and convection in multi-component mixtures; steady state, quasi-steady state and transient mass transfer; effect of reactions on mass transfer; convective mass transfer; simultaneous mass, heat and momentum transfer; applications to chemical and related industries.

(Design units: 1)
Prerequisite: CBEMS 125B
Overlaps with BME 150.
Restriction: Chemical Engineering Majors have first consideration for enrollment.

CBEMS 128. Introduction to Numerical Methods in Engineering. 3 Units.
An introduction to the fundamentals of numerical analysis and the computer algorithms in MATLAB for the solution of engineering problems, with emphasis on problems arising in chemical engineering thermodynamics, transport phenomena, and reaction engineering.

(Design units: 0)
Prerequisite: CBEMS 45C

CBEMS 130. Separation Processes. 4 Units.
Application of equilibria and mass and energy balances for design of separation processes. Use of equilibrium laws for design of distillation, absorption, stripping, and extraction equipment. Design of multicomponent separators.

(Design units: 3)
Prerequisite: (CBEMS 45B or CBEMS 65A or ENGRMAE 91) and (CBEMS 45C or CBEMS 65B or ENGRMAE 115). CBEMS 45B with a grade of C- or better. CBEMS 65A with a grade of C- or better. ENGRMAE 91 with a grade of C- or better. CBEMS 45C with a grade of C- or better. CBEMS 65B with a grade of C- or better. ENGRMAE 115 with a grade of C- or better
Restriction: Chemical Engineering Majors have first consideration for enrollment. Materials Science Engineering Majors have first consideration for enrollment.
CBEMS 133. Nuclear and Radiochemistry. 4 Units.
Advanced treatment of nuclear structure, nuclear reactions, and radioactive-decay processes. Introduction to nuclear activation analysis, isotope effects, radiation chemistry, hot-atom chemistry, nuclear age-dating methods, nuclear reactors, and nuclear power.

(Design units: 0)
Prerequisite: (CHEM M3C or CHEM 1C or CHEM H2C) and MATH 2D
Same as CHEM 133.
Overlaps with CHEM 170.
Restriction: Chemistry Majors have first consideration for enrollment. Chemical Engineering Majors have first consideration for enrollment. Materials Science Engineering Majors have first consideration for enrollment. CHEM 133 and CHEM 170 cannot both be taken for credit.
Concurrent with CBEMS 233 and CHEM 233.

CBEMS 135. Chemical Process Control. 4 Units.
Dynamic responses and control of chemical process equipment, dynamic modeling of chemical processes, linear system analysis, analyses and design of feedback loops and advanced control systems.

(Design units: 1)
Prerequisite: CBEMS 110 and CBEMS 125B and CBEMS 125C
Restriction: Chemical Engineering Majors have first consideration for enrollment.

CBEMS 140A. Chemical Engineering Laboratory I. 4 Units.
Experimental study of thermodynamics, fluid mechanics, and heat and mass transfer. Operation and evaluation of process equipment, data analysis. Materials fee.

(Design units: 1)
Prerequisite: CBEMS 110 and (CBEMS 125C or BME 150)
Restriction: Chemical Engineering Majors have first consideration for enrollment.

CBEMS 140B. Chemical Engineering Laboratory II. 4 Units.
Continuation of the CBEMS 140A covering mass transfer operations such as distillation, absorption, extraction, etc. Rate and equilibria studies in simple chemical systems with and without reaction. Study of chemical process. Materials fee.

(Design units: 3)
Prerequisite: CBEMS 130 and CBEMS 135 and CBEMS 140A
Restriction: Chemical Engineering Majors have first consideration for enrollment.

CBEMS 141. Nano-Scale Materials and Applications. 4 Units.
Overview of the chemistry, physics, and applications of nanometer-scale materials. Explore the effects of composition, bonding, and confinement on physical properties of nanomaterials, their chemical syntheses, and their device physics in electronic, optoelectronic, and energy technologies.

(Design units: 1)
Prerequisite: (ENGR 1A or CHEM 1A) and MATH 2B and PHYSICS 7D
Concurrent with CBEMS 241.

CBEMS 143. Chemistry and Technology for the Nuclear Fuel Cycle. 4 Units.
Introduces basic concepts of nuclear chemistry and focuses on chemical engineering aspects of the nuclear power industry. A broad survey of the nuclear fuel cycle (uranium processing, reactor concepts, spent fuel treatment and repositories) will be given.

(Design units: 0)
Concurrent with CBEMS 243.
CBEMS 149A. Chemical Engineering Design I. 3 Units.
Introduction to process design; flow sheets for chemical processes; synthesis of multicomponent separation sequences and reaction paths; synthesis of heat exchange networks; computer-aided design and simulation of processes and components pacts.

(Design units: 2)
Prerequisite: CBEMS 110 and CBEMS 125C and CBEMS 130
Restriction: Chemical Engineering Majors only.

CBEMS 149B. Chemical Engineering Design II. 3 Units.
Application of chemical engineering basics to practical design problems; process economics; process safety; environmental impacts; a major team design project with progress reports, oral presentation, and technical report with engineering drawings and economics.

(Design units: 3)
Prerequisite: CBEMS 149A
Restriction: Chemical Engineering Majors only.

CBEMS 154. Polymer Science and Engineering. 4 Units.
An introduction to physical aspects of polymers, including configuration and conformation of polymer chains and characterization techniques; crystallinity, viscoelasticity, mechanical properties, polymer alloys, processing, and application.

(Design units: 1)
Prerequisite: ENGR 54 and (CBEMS 110 or CBEMS 165)
Restriction: Chemical Engineering Majors have first consideration for enrollment. Materials Science Engineering Majors have first consideration for enrollment.
Concurrent with ENGRMSE 254.

CBEMS 155. 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 ENGRMAE 156.
Restriction: Chemical Engineering Majors have first consideration for enrollment. Materials Science Engineering Majors have first consideration for enrollment. Mechanical Engineering Majors have first consideration for enrollment.

CBEMS 155L. Mechanical Behavior Laboratory. 1 Unit.
Introduction to experimental techniques to characterize mechanical properties of materials. Emphasis on correlations between property and microstructure. Experiments include: plastic stability in tension, effect of grain size on flow stress, microstructural engineering. Materials fee.

(Design units: 0)
Corequisite: CBEMS 155
Prerequisite: ENGR 54
Restriction: Materials Science Engineering Majors have first consideration for enrollment.

CBEMS 158. Ceramic Materials. 3 Units.
A technical elective for students interested in the materials area. Topics covered include structure and properties of ceramics, and design with ceramics.

(Design units: 1)
Prerequisite: ENGR 54
Restriction: Chemical Engineering Majors have first consideration for enrollment. Materials Science Engineering Majors have first consideration for enrollment.
CBEMS 160. Advanced Lab in Synthesis of Materials. 4 Units.
Synthesis and characterization of organic and inorganic materials including polymers and oxides. Techniques include electron and scanning probe microscopy, gel permeation chromatography, X-ray diffraction, porosimetry, and thermal analysis. Materials fee.

(Design units: 0)
Prerequisite: ENGR 54 or (CHEM 131A and CHEM 131B)
Restriction: Materials Science Engineering Majors have first consideration for enrollment.

CBEMS 163. Computer Techniques in Experimental Research. 4 Units.
Principles and practical guidelines of automated materials testing. Computer fundamentals, programming languages, data acquisition and control hardware, interfacing techniques, programming strategies, data analysis, data storage, safeguard procedures.

(Design units: 1)
Restriction: Chemical Engineering Majors have first consideration for enrollment. Materials Science Engineering Majors have first consideration for enrollment.

Concurrent with ENGRMSE 263.

CBEMS 164. X-ray Diffraction, Electron Microscopy, and Microanalysis. 3 Units.
Material characterization using X-ray diffraction and scanning electron microscopy (SEM). Topics include X-ray diffraction and analysis; SEM imaging and microanalysis. Materials fee.

(Design units: 1)
Corequisite: CBEMS 164L
Prerequisite: ENGR 54
Restriction: Materials Science Engineering Majors have first consideration for enrollment.

CBEMS 164L. X-ray Diffraction, Electron Microscopy, and Microanalysis Lab. 2 Units.
Material characterization using X-ray diffraction and scanning electron microscopy (SEM). Topics include X-ray diffraction and analysis; SEM imaging and microanalysis.

(Design units: 1)
Corequisite: CBEMS 164
Prerequisite: ENGR 54
Restriction: Materials Science Engineering Majors have first consideration for enrollment.

CBEMS 165. Materials Kinetics and Phase Transformations. 3 Units.
Treatment of the kinetics of solid-state reactions and reactions at interfaces. Thermodynamics and kinetics of phase transformations, including solidification processes, diffusional and diffusionless phase transformations.

(Design units: 0)
Prerequisite: ENGR 54 and (ENGRMAE 91 or CBEMS 45C or CBEMS 65B). ENGRMAE 91 with a grade of C- or better. CBEMS 45C with a grade of C- or better. CBEMS 65B with a grade of C- or better
Restriction: Materials Science Engineering Majors have first consideration for enrollment.

CBEMS 169. Electronic and Optical Properties in Materials. 4 Units.
Covers the electronic, optical, and dielectric properties of crystalline and amorphous materials to provide a foundation of the underlying physical principles governing the properties of existing and emerging electronic and photonic materials.

(Design units: 1)
Prerequisite: PHYSICS 7D and PHYSICS 7E and MATH 3A and MATH 3D
Restriction: Materials Science Engineering Majors have first consideration for enrollment.
CBEMS 174. Semiconductor Device Packaging. 3 Units.
Introduction to the semiconductor device packaging and assembly process. Electrical, thermal, optical, and mechanical aspects of package design and reliability. Special topics on optoelectronics packaging will be covered.

(Design units: 1)
Prerequisite: CBEMS 45B
Restriction: Chemical Engineering Majors have first consideration for enrollment. Materials Science Engineering Majors have first consideration for enrollment.

CBEMS 175. Design Failure Investigation. 4 Units.
Survey of mechanisms by which devices fail, including overload, fatigue, corrosion, and wear. Use of fractography and other evidence to interpret failure modes and specify design/manufacturing changes. Students redesign failed parts or structures based on actual parts and/or case histories.

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

CBEMS 176. Surface and Adhesion Science. 4 Units.
Structure, thermodynamics of, kinetics, and reactions on surfaces. Surface electronic and mechanical properties and characterization of all classes of materials including metals, semiconductors, ceramics, polymers, and soft materials. Adhesion between different materials is also addressed.

Prerequisite: (CBEMS 110 or CBEMS 165) and (CBEMS 141 or CBEMS 169)
Restriction: Chemical Engineering Majors have first consideration for enrollment. Materials Science Engineering Majors have first consideration for enrollment.

Concurrent with ENGRMSE 276.

CBEMS 189A. Senior Design Project I. 3 Units.
Group supervised senior design projects that deal with materials selection in engineering design and that involve case studies in ethics, safety, design, failure modes, new products, and patents. Activities conclude with a presentation of the projects. Materials fee.

(Design units: 2)
Grading Option: In progress only.
Restriction: Seniors only. Materials Science Engineering Majors only. CBEMS 189A-CBEMS 189B-CBEMS 189C must be taken in the same academic year.

CBEMS 189B. Senior Design Project II. 3 Units.
Group supervised senior design projects that deal with materials selection in engineering design and that involve case studies in ethics, safety, design, failure modes, new products, and patents. Activities conclude with a presentation of the projects. Materials fee.

(Design units: 3)
Prerequisite: CBEMS 189A
Grading Option: In progress only.
Restriction: Seniors only. Materials Science Engineering Majors only. CBEMS 189A-CBEMS 189B-CBEMS 189C must be taken in the same academic year.

CBEMS 189C. Senior Design Project III. 3 Units.
Group supervised senior design projects that deal with materials selection in engineering design and that involve case studies in ethics, safety, design, failure modes, new products, and patents. Activities conclude with a presentation of the projects. Materials fee.

(Design units: 3)
Prerequisite: CBEMS 189B
Restriction: Seniors only. Materials Science Engineering Majors only. CBEMS 189A-CBEMS 189B-CBEMS 189C must be taken in the same academic year.
CBEMS 190. Materials Selection and Design. 4 Units.

(Design units: 3)

Restriction: Seniors only. Materials Science Engineering Majors have first consideration for enrollment.

CBEMS 191. Materials Outreach. 3 Units.
Demonstrates major concepts in Materials Science and Engineering. Concepts of materials engineering covered include deformation in crystalline solids, effects of heat treatment on mechanical properties, thermal barrier materials, composites design, mechanical behavior of polymers, superconductivity in ceramics.

(Design units: 1)
Prerequisite: ENGR 54

Repeatability: May be taken for credit 4 times.

Restriction: Chemical Engineering Majors have first consideration for enrollment. Materials Science Engineering Majors have first consideration for enrollment.

CBEMS 195. Special Topics in Chemical Engineering and Materials Science. 1-4 Units.
Studies in selected areas of Chemical Engineering and Materials Science. Topics addressed vary each quarter.

(Design units: 0)
Prerequisite: Prerequisites vary.

Repeatability: Unlimited as topics vary.

CBEMS 198. Group Study. 1-4 Units.
Group study of selected topics in engineering.

(Design units: 1-4)

Repeatability: May be repeated for credit unlimited times.

Restriction: Upper-division students only.

CBEMS 199. Individual Study. 1-4 Units.
For undergraduate engineering majors in supervised but independent readings, 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.

Restriction: Chemical Engineering Majors have first consideration for enrollment. Materials Science Engineering Majors have first consideration for enrollment.

CBEMS 199P. 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)

Grading Option: Pass/no pass only.

Repeatability: May be repeated for credit unlimited times.

CBEMS 210. Reaction Engineering. 4 Units.
Advanced topics in reaction engineering, reactor stability analysis, diffusional effect in heterogeneous catalysis, energy balance, optimization of reactor operation, dispersed in phase reactors.

Restriction: Graduate students only.
CBEMS 215. Kinetics of Biochemical Networks. 4 Units.
Principles from statistical mechanics, thermodynamics, and chemical kinetics applied to biochemical systems, from fundamental processes such as receptor-ligand binding and enzyme catalysis, to complex cellular functions including signal transduction and gene regulation.
Restriction: Graduate students only.
Concurrent with CBEMS 115.

CBEMS 218. Bioengineering with Recombinant Microorganisms. 4 Units.
Engineering and biological principles important in recombinant cell technology. Host/vector selection; plasmid propagation; optimization of cloned gene expression; metabolic engineering; protein secretion; experimental techniques; modeling of recombinant cell systems.
Restriction: Graduate students only.

CBEMS 219. Biomaterials: Structural Biology and Assembly. 4 Units.
Application of fundamental concepts in structural biology (proteins, DNA/RNA, carbohydrates, lipids), biomolecular thermodynamics, and molecular interactions to the design of novel biomaterials via self-assembly.
Concurrent with CBEMS 119.

CBEMS 220. Transport Phenomena. 4 Units.
Heat, mass, and momentum transfer theory from the viewpoint of the basic transport equations. Steady and unsteady state; laminar and turbulent flow; boundary layer theory, mechanics of turbulent transport with specific application to complex chemical engineering situations.
Restriction: Graduate students only.

CBEMS 221. Drug Delivery. 4 Units.
Introduction to design of drug delivery systems. Includes physicochemical and pharmacokinetic considerations in drug formulations, types of therapeutics, routes of administration, biomaterials, and novel drug delivery systems.

CBEMS 228. Colloid Science and Engineering. 4 Units.
An introduction to the basic foundations of colloid science, interfacial phenomena, suspensions and complex fluids, and engineering and assembly of colloidal materials.
Restriction: Graduate students only.

Analytical techniques applied to engineering problems in transport phenomena, process dynamics and control, and thermodynamics.
Restriction: Graduate students only.

CBEMS 233. Nuclear and Radiochemistry. 4 Units.
Advanced treatment of nuclear structure, nuclear reactions, and radioactive-decay processes. Introduction to nuclear activation analysis, isotope effects, radiation chemistry, hot-atom chemistry, nuclear age-dating methods, nuclear reactors, and nuclear power.
Same as CHEM 233.
Restriction: Graduate students only.

CBEMS 240. Advanced Engineering Thermodynamics. 4 Units.
Introduction to modern thermodynamics and applications, with a focus on aspects relevant to chemical and materials engineering. Mathematical tools; equilibrium and stability; microscale rigorous equations of state; molecular-level thermodynamics of real mixtures; and phase and chemical equilibrium.
Restriction: Graduate students only.

CBEMS 241. Nano-Scale Materials and Applications. 4 Units.
Overview of the chemistry, physics, and applications of nanometer-scale materials. Explore the effects of composition, bonding, and confinement on physical properties of nanomaterials, their chemical syntheses, and their device physics in electronic, optoelectronic, and energy technologies.
Restriction: Graduate students only.
Concurrent with CBEMS 141.
CBEMS 242A. Physical and Geometrical Optics. 4 Units.
Focuses on the practical aspects of optics and optical engineering, starting at the fundamentals. Topics include geometrical optics, ray tracing, polarization optics, interferometers, and diffractive optics.

Same as CHEM 242A.

Restriction: Graduate students only.

Concurrent with PHYSICS 134A.

CBEMS 243. Chemistry and Technology for the Nuclear Fuel Cycle. 4 Units.
Introduces basic concepts of nuclear chemistry and focuses on chemical engineering aspects of the nuclear power industry. A broad survey of the nuclear fuel cycle (uranium processing, reactor concepts, spent fuel treatment and repositories) will be given.

Restriction: Graduate students only.

Concurrent with CBEMS 143.

CBEMS 244. Detection and Measurement of Radiation. 4 Units.
Basic principles of detection and measurement of ionizing radiation; both theory and practical aspects of measurement techniques for alpha, beta, gamma, and neutron radiation, properties of different detector materials, electronics and data treatments, and analysis.

Prerequisite: CHEM 233 or CBEMS 233

Same as CHEM 244.

Restriction: Graduate students only.

CBEMS 249. Special Topics in Chemical Engineering and Materials Science. 1-4 Units.
Studies in selected areas of Chemical Engineering and Materials Science. Topics addressed vary each quarter.

Prerequisite: Prerequisites vary.

Repeatability: Unlimited as topics vary.

Restriction: Graduate students only.

CBEMS 268. Seminar in Systems Microbiology Research. 1 Unit.
A research and journal club seminar that covers topics on bacteria and phage using approaches and principles from biology, engineering, and physics.

Grading Option: Satisfactory/unsatisfactory only.

Repeatability: May be repeated for credit unlimited times.

Same as PHYSICS 268, MBB 268.

Restriction: Upper-division students only. Graduate students only.

CBEMS 280. Optoelectronics Packaging. 4 Units.
Basic and current issues in the packaging of integrated circuits (IC) and fiber-optic devices are discussed.

Restriction: Graduate students only.

CBEMS 295. Seminars in Engineering. 1-4 Units.
Seminars scheduled each year by individual faculty in major field of interest.

Grading Option: Satisfactory/unsatisfactory only.

Repeatability: Unlimited as topics vary.

Restriction: Graduate students only.

CBEMS 296. Master of Science Thesis Research. 1-16 Units.
Individual research or investigation conducted in preparation for the thesis required for the M.S. degree.

Repeatability: May be repeated for credit unlimited times.

Restriction: Graduate students only.
CBEMS 297. Doctor of Philosophy Dissertation Research. 1-16 Units.
Individual research or investigation conducted in preparation for the dissertation required for the Ph.D. degree.
Repeatability: May be repeated for credit unlimited times.
Restriction: Graduate students only.

CBEMS 298. Seminars in Engineering. 2 Units.
Presentation of advanced topics and reports of current research efforts in chemical engineering and materials science.
Grading Option: Satisfactory/unsatisfactory only.
Repeatability: May be repeated for credit unlimited times.
Restriction: Graduate students only.

CBEMS 299. Individual Research. 1-16 Units.
Individual research or investigation under the direction of an individual faculty member.
Grading Option: Satisfactory/unsatisfactory only.
Repeatability: May be repeated for credit unlimited times.
Restriction: Graduate students only.

Civil and Environmental Engr Courses

ENGRCEE 11. Methods II: Probability and Statistics. 4 Units.
Modeling and analysis of engineering problems under uncertainty. Engineering applications of probability and statistical concepts and methods.
(Design units: 0)
Prerequisite: (ENGRCEE 20 or EECS 10 or EECS 12 or ENGRMAE 10 or I&C SCI 31) and MATH 3A
Restriction: Civil Engineering Majors have first consideration for enrollment. Environmental Engineering Majors have first consideration for enrollment.

ENGRCEE 20. Introduction to Computational Problem Solving. 4 Units.
Introduction to computer programming within a numerical computing environment (MATLAB or similar) including types of data representation, graphical display of data, and development of modular programs with application to engineering analysis and problem solving. Course may be offered online.
(Design units: 1)
Corequisite: MATH 3A
Overlaps with BME 60B.
Restriction: Civil Engineering Majors have first consideration for enrollment. Environmental Engineering Majors have first consideration for enrollment.

ENGRCEE 21. Computational Problem Solving. 4 Units.
Engineering analysis and problem solving using MATLAB (or similar), including matrix algebra, solving systems of linear and nonlinear equations, numerical integration of ordinary differential equations (ODEs) and coupled ODEs, and analysis of numerical errors. Course may be offered online.
(Design units: 1)
Corequisite: MATH 3D
Prerequisite: ENGRCEE 20 and MATH 3A
Restriction: Civil Engineering Majors have first consideration for enrollment. Environmental Engineering Majors have first consideration for enrollment.
ENGRCEE 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 ENGR 30, ENGRMAE 30.

Restriction: School of Engineering students have first consideration for enrollment.

ENGRCEE 60. Contemporary and Emerging Environmental Challenges. 4 Units.
Introduces contemporary and emerging environmental challenges, illustrates links between human behavior, environmental policy, and engineering practices, examines policy options in the context of current institutions, and introduces tools and frameworks to reach sound economic, social, and environmental solutions. Course may be offered online.

(Design units: 0)

(III)

ENGRCEE 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 ENGR 80, ENGRMAE 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.

ENGRCEE 81A. Civil Engineering Practicum I. 3 Units.
Introduction to civil engineering through presentations on structural, environmental, water, and transportation systems. Introduction to graphics. Graphical visualization and communication using hand and computer sketching. Fundamentals of Computer Aided Design (CAD) using AutoCad. Laboratory sessions. Materials fee.

(Design units: 2)

Restriction: Civil Engineering Majors have first consideration for enrollment. Environmental Engineering Majors have first consideration for enrollment.

ENGRCEE 81B. Civil Engineering Practicum II. 3 Units.
Principles of surveying; fundamentals of Geographic Information Systems (GIS); introduction to the state-of-the-art and future areas of the profession, including applications of advanced technology and computers; Introduction to visualization and communication of design concepts; laboratory sessions. Course may be offered online. Materials fee.

(Design units: 1)

Restriction: Civil Engineering Majors have first consideration for enrollment. Environmental Engineering Majors have first consideration for enrollment.

ENGRCEE 110. Methods III: Modeling, Economics, and Management. 4 Units.
Analysis, modeling, and management of civil engineering systems. Statistics and system performance studies, probabilistic models and simulation, basic economics and capital investments, project elements and organization, managerial concepts and network technique, project scheduling. Emphasis on real-world examples. Laboratory sessions.

(Design units: 1)

Prerequisite: ENGRCEE 11

Restriction: Civil Engineering Majors have first consideration for enrollment. Environmental Engineering Majors have first consideration for enrollment.
ENGRCEE 111. Methods IV: Systems Analysis and Decision-Making. 4 Units.
Analysis and optimization for decision-making in civil and infrastructural systems. Topics include linear programming formulations and solution algorithms, network models, and logistical models. Emphasis is on project-level and managerial decision-making and selection from alternative designs.

(Design units: 1)
Prerequisite: MATH 3A and MATH 3D
Restriction: Civil Engineering Majors have first consideration for enrollment.

ENGRCEE 121. Transportation Systems I: Analysis and Design. 4 Units.
Introduction to analysis and design of fundamental transportation system components, basic elements of geometric and pavement design, vehicle flow and elementary traffic, basic foundations of transportation planning and forecasting. Laboratory sessions.

(Design units: 2)
Prerequisite: ENGRCEE 11 and ENGRCEE 81A
Restriction: Civil Engineering Majors have first consideration for enrollment.

ENGRCEE 122. Transportation Systems II: Operations & Control. 4 Units.
Introduction to fundamentals of urban traffic engineering, including data collection, analysis, and design. Traffic engineering studies, traffic flow theory, traffic control devices, traffic signals, capacity and level of service analysis of freeways and urban streets. Laboratory sessions.

(Design units: 2)
Prerequisite: ENGRCEE 11 and ENGRCEE 121
Restriction: Civil Engineering Majors have first consideration for enrollment.

ENGRCEE 123. Transportation Systems III: Planning and Forecasting. 4 Units.
Theoretical foundations of transportation planning, design, and analysis methods. Theory and application of aggregate and disaggregate models for land use development, trip generation, destination, mode, and route choice. Transportation network analysis. Planning, design, and evaluation of system alternatives.

(Design units: 2)
Corequisite: ENGRCEE 110
Prerequisite: ENGRCEE 121
Restriction: Civil Engineering Majors have first consideration for enrollment.

Concurrent with ENGRCEE 223.

ENGRCEE 124. Transportation Systems IV: Freeway Operations and Control. 4 Units.
Fundamentals of traffic on urban freeways, including data collection analysis, and design. Traffic engineering studies, traffic flow theory, freeway traffic control devices, capacity, and level of service analysis of freeways and highways. Laboratory sessions.

(Design units: 2)
Prerequisite: ENGRCEE 121
Restriction: Civil Engineering Majors have first consideration for enrollment.

ENGRCEE 130. Soil Mechanics. 4 Units.
Mechanics of soils, composition and classification of soils, compaction, compressibility and consolidation, shear strength, seepage, bearing capacity, lateral earth pressure, retaining walls, piles.

(Design units: 0)
Corequisite: ENGRCEE 130L
Prerequisite: ENGRCEE 150 and ENGRCEE 170
Restriction: Civil Engineering Majors have first consideration for enrollment. Environmental Engineering Majors have first consideration for enrollment.
ENGRCEE 130L. Soil Mechanics Laboratory. 1 Unit.
Laboratory procedures of soil testing for engineering problems. Materials fee.

(Design units: 0)
Corequisite: ENGRCEE 130
Restriction: Civil Engineering Majors have first consideration for enrollment. Environmental Engineering Majors have first consideration for enrollment.

ENGRCEE 149. Introduction to Earthquake Engineering. 4 Units.
Plate tectonics. Structural dynamics. Earthquake magnitude, intensity, and frequency. Seismic damage to structures. Earthquake load prediction including response spectra, normal mode, and direct integration techniques. The basis of building code earthquake load requirements for buildings.

(Design units: 2)
Prerequisite: ENGRCEE 11 and ENGRCEE 20 and ENGRCEE 151A
Restriction: Civil Engineering Majors have first consideration for enrollment.

ENGRCEE 150. Mechanics of Materials. 4 Units.
Stresses and strains, strain-stress diagrams, axial deformations, torsion, bending and shear stresses in beams, shear force and bending moment diagrams, combined stresses, principal stresses, Mohr's circle, deflection of beams, columns.

(Design units: 1)
Prerequisite: ENGRCEE 30
Overlaps with ENGR 150, ENGRMAE 150.
Restriction: Civil Engineering Majors have first consideration for enrollment. Environmental Engineering Majors have first consideration for enrollment.

ENGRCEE 150L. Mechanics of Materials Laboratory. 1 Unit.
Experimental methods and fundamentals for mechanics of materials analysis. Materials fee.

(Design units: 0)
Corequisite: ENGRCEE 150
Prerequisite: ENGRCEE 30
Overlaps with ENGRMAE 150L.
Restriction: Civil Engineering Majors have first consideration for enrollment. Environmental Engineering Majors have first consideration for enrollment.

ENGRCEE 151A. Structural Analysis. 4 Units.

(Design units: 0)
Prerequisite: ENGRCEE 150
Restriction: Civil Engineering Majors have first consideration for enrollment.

ENGRCEE 151B. Structural Timber Design. 4 Units.
Design of timber structures. Beams, columns, beam-columns, roof, and connections.

(Design units: 3)
Prerequisite: ENGRCEE 151A
Restriction: Civil Engineering Majors have first consideration for enrollment.
ENGRCEE 151C. Reinforced Concrete Design. 4 Units.

(Design units: 3)
Prerequisite: ENGRCEE 151A
Restriction: Civil Engineering Majors have first consideration for enrollment.

ENGRCEE 152. Computer Methods in Structural Analysis and Design. 4 Units.
Matrix techniques for indeterminate framed structures. Computer implementation using the stiffness method. Software packages for design of reinforced concrete, steel, and/or timber structures.

(Design units: 2)
Prerequisite: ENGRCEE 151C
Restriction: Civil Engineering Majors have first consideration for enrollment.

ENGRCEE 155. Structural Steel Design. 4 Units.
Design in steel of tension members, beams, columns, welded and bolted connections; eccentrically loaded and moment resistant joints; plate girders. Plastic design; load and resistance factor design. Composite construction; introduction to computer-aided design.

(Design units: 4)
Prerequisite: ENGRCEE 151A
Restriction: Civil Engineering Majors have first consideration for enrollment.

ENGRCEE 156. Foundation Design. 4 Units.
Applications of soil mechanics principles to the analysis and design of shallow foundations, retaining walls, pile foundations, and braced cuts. Design criteria: bearing capacity, working loads and tolerable settlements, structural integrity of the foundation element. Damage from construction operations.

(Design units: 3)
Prerequisite: ENGRCEE 130 and ENGRCEE 151C
Restriction: Civil Engineering Majors have first consideration for enrollment.

ENGRCEE 160. Environmental Processes. 4 Units.

(Design units: 1)
Prerequisite: CHEM 1B and ENGRCEE 170
Restriction: Civil Engineering Majors have first consideration for enrollment. Environmental Engineering Majors have first consideration for enrollment.

ENGRCEE 162. Introduction to Environmental Chemistry. 4 Units.
Basic concepts from general, physical, and analytical chemistry as they relate to environmental engineering. Particular emphasis on the fundamentals of equilibrium and kinetics as they apply to acid-base chemistry, gas solubility, and redox reactions. Laboratory sessions. Materials fee.

(Design units: 0)
Prerequisite: (ENGR 1A or CHEM 1A) and CHEM 1B and (CHEM 1LC or CHEM 1LE) and CHEM 51A
Restriction: Chemical Engineering Majors have first consideration for enrollment. Civil Engineering Majors have first consideration for enrollment. Environmental Engineering Majors have first consideration for enrollment. Mechanical Engineering Majors have first consideration for enrollment.
ENGRCEE 163. Wastewater Treatment Process Design. 4 Units.
Design of biological treatment processes. Topics include attached and suspended growth, aeration, anaerobic systems, process control, and economics. Design projects included. Materials fee.

(Design units: 4)
Prerequisite: ENGRCEE 160
Restriction: Civil Engineering Majors have first consideration for enrollment. Environmental Engineering Majors have first consideration for enrollment.

ENGRCEE 164. Carbon and Energy Footprint Analysis. 4 Units.
Process design for wastewater treatment. Mass- and energy-balance analysis applied to water and wastewater treatment systems. Case studies include analysis of water supply, treatment, reclamation, and reuse.

(Design units: 2)
Prerequisite: ENGRCEE 160
Restriction: Civil Engineering Majors have first consideration for enrollment. Environmental Engineering Majors have first consideration for enrollment.
Concurrent with ENGRCEE 264.

ENGRCEE 165. Physical-Chemical Treatment Processes. 4 Units.
Theory and dynamics of physical and chemical separation processes in water and wastewater treatment. Topics include coagulation, sedimentation, filtration, gas-transfer, membrane separations, and adsorption.

(Design units: 2)
Prerequisite: ENGRCEE 160 and (ENGRMAE 91 or CBEMS 45C)
Restriction: Civil Engineering Majors have first consideration for enrollment. Environmental Engineering Majors have first consideration for enrollment.
Concurrent with ENGRCEE 265.

ENGRCEE 169. Environmental Microbiology for Engineers. 4 Units.
Fundamental and applied principles of microbiology. Structures and functions of microorganisms, the microbiology of water, wastewater and soil used in environmental engineering, and the impact of microorganisms on human and environmental health.

(Design units: 0)
Prerequisite: ENGRCEE 160
Restriction: Civil Engineering Majors have first consideration for enrollment. Environmental Engineering Majors have first consideration for enrollment.

ENGRCEE 170. Introduction to Fluid Mechanics. 4 Units.
Thermodynamic and mechanical fluid properties; fluid statics; control volume and differential approaches for mass, momentum, and energy; dimensional analysis and similarity.

(Design units: 1)
Corequisite: MATH 2E and ENGRCEE 20
Prerequisite: PHYSICS 7C
Overlaps with ENGRMAE 130A, CBEMS 125A.
Restriction: Civil Engineering Majors have first consideration for enrollment. Environmental Engineering Majors have first consideration for enrollment.

ENGRCEE 171. Water Resources Engineering. 4 Units.
Principles governing the analysis and design of water resource systems including pressurized pipelines, pipe networks, channels, and ground water. Coverage of fluid mass, momentum and energy conservation, flow resistance, and related laboratory measurements in different systems. Materials fee.

(Design units: 2)
Prerequisite: ENGRCEE 170
Restriction: Chemical Engineering Majors have first consideration for enrollment. Civil Engineering Majors have first consideration for enrollment. Environmental Engineering Majors have first consideration for enrollment.
ENGRCEE 172. Groundwater Hydrology. 4 Units.
Topics include conservation of fluid mass, storage properties of porous media, matrix compressibility, boundary conditions, flow nets, well hydraulics, groundwater chemistry, and solute transport. Design projects and computer applications included.

(Design units: 2)
Prerequisite: ENGRCEE 170
Restriction: Chemical Engineering Majors have first consideration for enrollment. Civil Engineering Majors have first consideration for enrollment. Environmental Engineering Majors have first consideration for enrollment.
 Concurrent with ENGRCEE 272.

ENGRCEE 173. Watershed Modeling. 4 Units.
Basic principles of hydrologic modeling are practiced. Concepts of watershed delineation, land use change impact, design studies, and GIS tools are discussed. Focus on the USACE (HEC) software tools (HEC-HMS, and HEC-RAS) along with their associated GIS interfaces.

(Design units: 1)
Prerequisite: ENGRCEE 170 and ENGRCEE 176
Restriction: Civil Engineering Majors have first consideration for enrollment. Environmental Engineering Majors have first consideration for enrollment. Mechanical Engineering Majors have first consideration for enrollment.
 Concurrent with ENGRCEE 273.

ENGRCEE 176. Hydrology. 4 Units.
Elements of the hydrologic cycle including precipitation, infiltration, evapotranspiration, ground water, and runoff. Unit Hydrograph theory and routing methods. Introduction to precipitation/runoff relationship and watershed modeling. Statistical methods and flood frequency analysis.

(Design units: 2)
Prerequisite: ENGRCEE 170 or ENGRMAE 130A
Restriction: Civil Engineering Majors have first consideration for enrollment. Environmental Engineering Majors have first consideration for enrollment.
 Concurrent with ENGRCEE 276.

ENGRCEE 178. Fluid Mechanics of Open Channels. 4 Units.
Fundamentals of fluid motion in open channels. Navier-Stokes equations and one-dimensional momentum and energy principles. Topics include rapidly varied flow, flow resistance and turbulence, gradually varied flow, unsteady flow, and computational methods for channel flow modeling.

(Design units: 1)
Prerequisite: (ENGRCEE 20 or ENGRMAE 10) and (ENGRCEE 170 or ENGRMAE 130A)
Restriction: Civil Engineering Majors have first consideration for enrollment. Environmental Engineering Majors have first consideration for enrollment.
 Concurrent with ENGRCEE 278.

ENGRCEE 181A. Senior Design Practicum I. 2 Units.
Team designs land development project including infrastructural, environmental, circulation aspects. Focus on traffic impact studies, design of roads, geometry, signals, geotechnical and hydrological analysis, design of structural elements, economic analysis. Oral/Written interim and final design reports. Laboratory sessions.

(Design units: 1)
Prerequisite: ENGRCEE 81A and ENGRCEE 81B and ENGRCEE 110 and (ENGRCEE 121 or ENGRCEE 151C or ENGRCEE 162 or ENGRCEE 171). ENGRCEE 181A and ENGRCEE 181B and ENGRCEE 181C must be taken in the same academic year.
Restriction: Civil Engineering Majors only. Environmental Engineering Majors only.
ENGRCEE 181B. Senior Design Practicum II. 2 Units.
Team designs land development project including infrastructural, environmental, circulation aspects. Focus on traffic impact studies, design of roads, geometry, signals, geotechnical and hydrological analysis, design of structural elements, economic analysis. Oral/Written interim and final design reports. Laboratory sessions.

(Design units: 2)
Corequisite: ENGRCEE 130
Prerequisite: ENGRENGRCEE 181A. CEE 181A and ENGRCEE 181B and ENGRCEE 181C must be taken in the same academic year.
Grading Option: In progress only.
Restriction: Civil Engineering Majors only. Environmental Engineering Majors only.

ENGRCEE 181C. Senior Design Practicum III. 2 Units.
Team designs land development project including infrastructural, environmental, circulation aspects. Focus on traffic impact studies, design of roads, geometry, signals, geotechnical and hydrological analysis, design of structural elements, economic analysis. Oral/Written interim and final design reports. Laboratory sessions.

(Design units: 2)
Prerequisite: ENGRENGRCEE 181B. ENGRCEE 181A and CEE 181B and ENGRCEE 181C must be taken in the same academic year.
Restriction: Civil Engineering Majors only. Environmental Engineering Majors only.

ENGRCEE 195. Special Topics in Civil and Environmental Engineering. 1-4 Units.
Studies in selected areas of Civil and Environmental Engineering. Topics addressed vary each quarter.

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

ENGRCEE 198. Group Study. 1-4 Units.
Group study of selected topics in Civil and Environmental Engineering.

(Design units: 1-4)
Repeatability: May be repeated for credit unlimited times.
Restriction: Upper-division students only.

ENGRCEE 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.

ENGRCEE 199P. Individual Study. 1-4 Units.
Supervised independent reading, research, or design for undergraduate Engineering majors. 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)
Grading Option: Pass/no pass only.
Repeatability: May be repeated for credit unlimited times.

ENGRCEE 220A. Travel Demand Analysis I. 4 Units.

Restriction: Graduate students only.
ENGRCEE 220B. Travel Demand Analysis II. 4 Units.
Methods of discrete choice analysis and their applications in the modeling of transportation systems. Emphasis on the development of a sound understanding of theoretical aspects of discrete choice modeling that are useful in many applications in travel demand analysis.

Prerequisite: ENGRCEE 220A

Restriction: Graduate students only.

ENGRCEE 220C. Travel Demand Analysis III: Activity-based Approaches. 4 Units.
The methodological underpinnings of activity-based travel demand modeling. Presents methodologies within the context of a generalization of discrete choice modeling approaches, emphasizing the distinctions that separate these two approaches and presenting appropriate mathematical and statistical tools to address these distinctions.

Prerequisite: ENGRCEE 220A

Restriction: Graduate students only.

ENGRCEE 221A. Transportation Systems Analysis I. 4 Units.
Introduction to mathematical methods and models to address logistics and urban transportation problems. Techniques include stochastic models, queueing theory, linear programming, and introductory non-linear optimization.

Restriction: Graduate students only.

ENGRCEE 221B. Transportation Systems Analysis II. 4 Units.
Advanced mathematical methods and models to address logistics and urban transportation problems. Topics include network flows, advanced optimization techniques, network models, and heuristic algorithms.

Prerequisite: ENGRCEE 221A

Restriction: Graduate students only.

ENGRCEE 222. Transit Systems Planning. 4 Units.
Planning methods for public transportation in urban areas. Technological and operating characteristics of vehicles, facilities, and systems. Short-range planning techniques: data collection and analysis, demand analysis, mode choice, operational strategies, financial analysis. Design of systems to improve performance.

Restriction: Graduate students only.

ENGRCEE 223. Transportation Systems III: Planning and Forecasting. 4 Units.
Theoretical foundations of transportation planning, design, and analysis methods. Theory and application of aggregate and disaggregate models for land use development, trip generation, destination, mode, and route choice. Transportation network analysis. Planning, design, and evaluation of system alternatives.

Restriction: Graduate students only.

Concurrent with ENGRCEE 123.

ENGRCEE 224A. Transportation Data Analysis I. 4 Units.
Statistical analysis of transportation data sources. Analysis of categorical and ordinal data. Regression and advanced multivariate analysis methods such as discriminant analysis, canonical correlation, and factor analysis. Sampling techniques, sample error and bias, survey instrument design.

Restriction: Graduate students only.

ENGRCEE 225B. Transportation Planning Models II. 4 Units.
Design and application of comprehensive transportation models. Network development, demand modeling, and equilibrium assignment. Model calibration, validation, prediction, and evaluation. Regional modeling, site impact analysis, and circulation studies. Design of transportation alternatives.

Prerequisite: ENGRCEE 223

Restriction: Graduate students only.

ENGRCEE 226A. Traffic Flow Theory I. 4 Units.

Restriction: Graduate students only.
ENGRCEE 226B. Traffic Flow Theory II. 4 Units.
Prerequisite: ENGRCEE 226A
Restriction: Graduate students only.

ENGRCEE 228A. Urban Transportation Networks I. 4 Units.
Analytical approaches and algorithms to the formulation and solution of the equilibrium assignment problem for transportation networks. Emphasis on user equilibrium (UE) comparison with system optimal, mathematical programming formulation, supply functions, estimation. Estimating origin-destination matrices, network design problems.
Prerequisite: ENGRCEE 220A
Restriction: Graduate students only.

ENGRCEE 228B. Urban Transportation Networks II. 4 Units.
Advanced analysis, optimization, and modeling of transportation networks. Topics include advanced static and dynamic traffic assignment algorithms, linear and nonlinear multi-commodity network flow optimization, network simplex, and network control problems.
Prerequisite: ENGRCEE 221A and ENGRCEE 228A
Restriction: Graduate students only.

ENGRCEE 229A. Traffic Systems Operations and Control I. 4 Units.
Introduction to operation, control and analysis of arterial and freeway traffic systems. Control concepts, traffic stream principles, detectors, local controllers, system masters, traffic signal and ramp metering timing principles, traffic measurement technologies, traffic delay principles.
Restriction: Graduate students only.

ENGRCEE 229B. Traffic Systems Operations and Control II. 4 Units.
Advanced topics related to operation, control, and analysis of arterial and freeway traffic systems. Control concepts, traffic stream principles, detectors, local controllers, system masters, traffic signal and ramp metering timing principles.
Prerequisite: ENGRCEE 229A
Restriction: Graduate students only.

ENGRCEE 231. Foundation Engineering. 4 Units.
Essentials for design and analysis of structural members that transmit superstructure loads to the ground. Topics include subsurface investigations, excavation, dewatering, bracing, footing, mat foundations, piles and pile foundations, caissons and cofferdams, other special foundations.
Restriction: Graduate students only.

ENGRCEE 232. Geotech Earthquake Engineering. 4 Units.
In-situ and laboratory determination of dynamic soil properties, liquefaction of soil, cyclic softening of clays, seismic compression and settlement analyses, ground improvement methods, seismic slope stability, introduction to soil structure interaction.
Restriction: Graduate students only.

ENGRCEE 242. Advanced Strength of Materials. 4 Units.
Restriction: Graduate students only.

ENGRCEE 243. Mechanics of Composite Materials. 4 Units.
Stress-strain relationship for orthotropic materials; invariant properties of an orthotropic lamina; biaxial strength theory for an orthotropic lamina; mechanics of materials approach to stiffness; elasticity approach to stiffness; classical lamination theory; strength of laminates; statistical theory of fatigue damage.
Restriction: Graduate students only.
ENGRCEE 247. Structural Dynamics. 4 Units.

Restriction: Graduate students only.

ENGRCEE 249. Earthquake Engineering. 4 Units.
Earthquake magnitude, intensity, and frequency. Seismic damage to structures. Earthquake load prediction including response spectra, normal mode, and direct integration techniques. The basis of building code earthquake load requirements for buildings. Seismic response of special structures. Lifeline engineering.

Restriction: Graduate students only.

ENGRCEE 250. Finite Element Method in Structural Engineering. 4 Units.
Finite element concepts in structural engineering including variational formulations, shape functions, elements assembly, convergence and computer programming. Stiffness of truss, beam, and frame members, two- and three-dimensional solids, plate and shell elements. Static, vibration, stability, and inelastic analysis.

Restriction: Graduate students only.

ENGRCEE 254. Advanced Reinforced Concrete Behavior and Design. 4 Units.

Restriction: Graduate students only.

ENGRCEE 255. Advanced Behavior and Design of Steel Structures. 4 Units.
Advanced principles of structural steel design. Analysis and design of beam-column members, braced and unbraced frames for buildings, and plate girders. Review of seismic design provisions. Design of connections.

Restriction: Graduate students only.

ENGRCEE 258. Earthquake Resistant Structural Design. 4 Units.

Restriction: Graduate students only.

ENGRCEE 260. Desalination. 4 Units.
Introduction of state of technology, costs and benefits, environmental issues, and implementation issues related to desalination. Emphasis on membrane processes and biofouling prevention.

Restriction: Graduate students only.

ENGRCEE 261. Applied Environmental Microbiology. 4 Units.
Microbes in the environment and their impact on human interactions. Microbiological application in solving environmental engineering problems.

Restriction: Graduate students only.

ENGRCEE 262. Environmental Chemistry II. 4 Units.
Advanced concepts from physical and organic chemistry as they relate to environmental engineering. Emphasis on equilibrium and kinetics as they apply to redox reactions, coordination, absorption, gas phase reactions, and ion exchange.

Restriction: Graduate students only.

ENGRCEE 263. Advanced Biological Treatment Processes. 4 Units.
Analysis of biological processes in natural and engineered systems. Biological treatment processes, both aerobic and anaerobic, with emphasis on suspended growth systems including design consideration. Containment degradation or control covered. Includes laboratory on molecular tools used in wastewater treatment.

Restriction: Graduate students only.
ENGRCEE 264. Carbon and Energy Footprint Analysis. 4 Units.
Process design for wastewater treatment. Mass- and energy- balance analysis applied to water and wastewater treatment systems. Case studies include analysis of water supply, treatment, reclamation, and reuse.

Restriction: Graduate students only.

Concurrent with ENGRCEE 164.

ENGRCEE 265. Physical-Chemical Treatment Processes. 4 Units.
Theory and dynamics of physical and chemical separation processes in water and wastewater treatment. Topics include coagulation, sedimentation, filtration, gas transfer, membrane separations, and absorption.

Restriction: Graduate students only.

Concurrent with ENGRCEE 165.

ENGRCEE 266. Drinking Water and Wastewater Biotechnology. 4 Units.
Water and wastewater microbiology. Engineering principles, molecular aspects, and overview of microorganisms of importance to public health. Topics include aerobic and anaerobic wastewater treatment and disinfection of pathogens in water, wastewaters, and biosolids.

Restriction: Graduate students only.

ENGRCEE 267. Energy, Climate Change, and Urban Air Quality. 4 Units.
An introduction to the connection between energy, climate change, and urban air quality. It will focus on air quality and climate implications of energy choices, bringing light to the most important and time-relevant issues.

Restriction: Graduate students only.

ENGRCEE 271. Flow in Unsaturated Porous Media. 4 Units.
Fluid flow in the unsaturated zone (zone of aeration) of the subsurface. Soil-water physics, flow in regional groundwater systems, miscible displacement, mathematical modeling techniques.

Restriction: Graduate students only.

ENGRCEE 272. Groundwater Hydrology. 4 Units.
Topics include conservation of fluid mass, storage properties or porous media, matrix compressibility, boundary conditions, flow nets, well hydraulics, groundwater chemistry, and solute transport. Includes introduction to advanced topics in porous media. Design projects and computer applications included.

Restriction: Graduate students only.

Concurrent with ENGRCEE 172.

ENGRCEE 273. Watershed Modeling. 4 Units.
Basic principles of hydrologic modeling are practiced. Concepts of watershed delineation, land use change impact, design studies, and GIS tools are discussed. Focus on the USACE (HEC) software tools (HEC-HMS and HEC-RAS) along with their associated GIS interfaces.

Restriction: Graduate students only.

Concurrent with ENGRCEE 173.

ENGRCEE 274. Climate Data Analysis. 4 Units.
Trend analysis; statistical indices for diagnosing and detecting changes in extremes; nonstationary processes; extreme value analysis; multivariate extreme value methods; tail dependence estimation; uncertainties in observed and projected changes in climate extremes.

ENGRCEE 275. Topics in Coastal Engineering. 4 Units.
Linear wave theory. Wave properties: particle kinematics, energy propagation, shoaling, refraction, reflection, diffraction, and breaking. Wave statistics and spectra. Selected topics from: design of coastal structures; harbor engineering; littoral transport and shoreline morphology; and hydrodynamics of estuaries.

Repeatability: May be repeated for credit unlimited times.

Restriction: Graduate students only.
ENGRCEE 276. Hydrology. 4 Units.
Elements of the hydrologic cycle including precipitation, infiltration, evapotranspiration, ground water, and runoff. Unit Hydrograph theory and routing methods. Introduction to precipitation/runoff relationship and watershed modeling. Statistical methods and flood frequency analysis. Discussion section covers advanced topics.

Restriction: Graduate students only.
Concurrent with ENGRCEE 176.

ENGRCEE 277. Hydrologic Transport Fundamentals. 4 Units.
Process description, mathematical and numerical modeling of transport processes in surface and ground water. Topics include advection, molecular diffusion, Taylor dispersion, mechanical dispersion in porous media, shear flow dispersion in channels, and turbulent jets and plumes.

Prerequisite: ENGRMAE 278
Restriction: Graduate students only.

ENGRCEE 278. Fluid Mechanics of Open Channels. 4 Units.
Fundamentals of fluid motion in open channels. Navier-Stokes equations and one-dimensional momentum and energy principles. Topics include rapidly varied flow, flow resistance and turbulence, gradually varied flow, unsteady flow, and computational methods for channel flow modeling.

Restriction: Graduate students only.
Concurrent with ENGRCEE 178.

ENGRCEE 279. Hydrologic Computational Modeling. 4 Units.
Computational modeling of multi-dimensional flow and scalar transport problems in surface and ground water. Topics include mathematical model formulation, numerical method selection, serial and parallel implementation, model verification and validation.

Prerequisite: ENGRCEE 272 and ENGRCEE 277 and ENGRCEE 278
Restriction: Graduate students only.

ENGRCEE 281. Structural Reliability. 4 Units.

Restriction: Graduate students only.

ENGRCEE 283. Mathematical Methods in Engineering Analysis. 4 Units.
Matrices; vector calculus; eigenvalue problems; Fourier analysis; partial differential equations; special functions; numerical analysis; finite difference method.

ENGRCEE 284. Engineering Decision and Risk Analysis. 4 Units.
Develops applications of statistical decision theory in engineering. Presents the fundamental tools used in engineering decision making and analysis of risk under conditions of uncertainty. All concepts are presented and illustrated thoroughly with engineering problems.

Restriction: Graduate students only.

ENGRCEE 289. Analysis of Hydrologic Systems. 4 Units.

ENGRCEE 290. Merging Models and Data. 4 Units.

Restriction: Graduate students only.
ENGRCEE 291. Hydrologic Remote Sensing. 4 Units.
Introduction to principles of remote sensing and application in hydrology. Review of sensor systems, thermal and multispectral image processing, and image classification. Examples from remote sensing of hydrologic processes such as precipitation, soil moisture, and vegetation are covered.

Prerequisite: ENGRCEE 276
Restriction: Graduate students only.

ENGRCEE 295. Seminars in Engineering. 1-4 Units.
Seminars scheduled each year by individual faculty in major field of interest.
Grading Option: Satisfactory/unsatisfactory only.
Repeatability: Unlimited as topics vary.
Restriction: Graduate students only.

ENGRCEE 296. Master of Science Thesis Research. 1-16 Units.
Individual research or investigation conducted in preparation of the thesis required for the M.S. degree in Engineering.
Grading Option: Satisfactory/unsatisfactory only.
Repeatability: May be repeated for credit unlimited times.
Restriction: Graduate students only.

ENGRCEE 297. Doctor of Philosophy Dissertation Research. 1-16 Units.
Individual research or investigation conducted in preparation for the dissertation required for the Ph.D. degree in Engineering.
Grading Option: Satisfactory/unsatisfactory only.
Repeatability: May be repeated for credit unlimited times.
Restriction: Graduate students only.

ENGRCEE 298. Special Topics in Civil Engineering. 1-4 Units.
Presentation of advanced topics and special research areas in civil engineering.
Repeatability: Unlimited as topics vary.
Restriction: Graduate students only.

ENGRCEE 299. Individual Research. 1-16 Units.
Individual research or investigation under the direction of an individual faculty member.
Grading Option: Satisfactory/unsatisfactory only.
Repeatability: May be repeated for credit unlimited times.
Restriction: Graduate students only.

Computer Sci and Engineering Courses

CSE 90. Systems Engineering and Technical Communications. 2 Units.
Introduces systems engineering concepts, including specifications and requirements, hardware and software design, integration, testing, and documentation. Emphasizes organization and writing of reports and effective presentations.

Restriction: Computer Science Engineering Majors have first consideration for enrollment.
CSE 112. Electronic Devices and Circuits. 4 Units.
A first course in the design of Very Large Scale Integrated (VLSI) systems. Introduction to CMOS technology; MOS transistors and CMOS circuits. Analysis and synthesis of CMOS gates. Layout design techniques for building blocks and systems. Introduction to CAD tools.

(Design units: 4)
Prerequisite: PHYSICS 7D and (CSE 70A or EECS 70A)
Overlaps with EECS 119, EECS 170D.
Restriction: Computer Science Engineering Majors have first consideration for enrollment.

CSE 199. Individual Study. 1-4 Units.
Supervised independent reading, research, or design for undergraduate Engineering majors. 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.

**Electrical Engr and Comp Sci Courses**

**EECS 1. Introduction to Electrical Engineering and Computer Engineering. 1 Unit.**
Introduction to the fields of Electrical Engineering and Computer Engineering, including possible careers in both traditional and new emerging areas. Background on both the Electrical Engineering and the Computer Engineering majors, curriculum requirements, specializations, and faculty research interests. Course may be offered online.

(Design units: 0)
Restriction: Electrical Engineering Majors have first consideration for enrollment. Computer Engineering Majors have first consideration for enrollment.

**EECS 10. Computational Methods in Electrical and Computer Engineering. 4 Units.**

(Design units: 0)
Corequisite: MATH 2A
Prerequisite: MATH 2A
Overlaps with EECS 12, I&C SCI 31.
Restriction: Electrical Engineering Majors have first consideration for enrollment. Chemical Engineering Majors have first consideration for enrollment.

**EECS 12. Introduction to Programming. 4 Units.**

(Design units: 0)
Corequisite: MATH 2A
Overlaps with EECS 10, I&C SCI 31.
Restriction: Computer Engineering Majors have first consideration for enrollment.

**EECS 20. Computer Systems and C Programming. 4 Units.**
Introduction to computing systems. Data representation and operations. Simple logic design. Basic computer organization. Instruction set architecture and assembly language programming. Introduction to C. Functions and recursion, data structures, pointers. Programming laboratory.

(Design units: 1)
Prerequisite: EECS 12
Restriction: Electrical Engineering Majors have first consideration for enrollment. Computer Engineering Majors have first consideration for enrollment.
EECS 22. Advanced C Programming. 3 Units.

(Design units: 1)
Prerequisite: EECS 10 or EECS 20
Restriction: Electrical Engineering Majors have first consideration for enrollment. Computer Engineering Majors have first consideration for enrollment.

EECS 22L. Software Engineering Project in C Language. 3 Units.
Hands-on experience with the ANSI-C programming language. Medium-sized programming projects, team work. Software specification, documentation, implementation, testing. Definition of data structures and application programming interface. Creation of program modules, linking with external libraries. Rule-based compilation, version control.

(Design units: 3)
Prerequisite: EECS 22
Restriction: Computer Engineering Majors have first consideration for enrollment.

EECS 31. Introduction to Digital Systems. 4 Units.
Digital representation of information. Specification, analysis, design and optimization or combinational and sequential logic, register-transfer components and register-transfer systems with datapaths and controllers. Introduction to high-level and algorithmic state-machines and custom processors.

(Design units: 2)
Prerequisite: I&C SCI 31 or EECS 10 or EECS 12 or ENGRMAE 10
Restriction: Computer Science Engineering Majors have first consideration for enrollment. Electrical Engineering Majors have first consideration for enrollment. Computer Engineering Majors have first consideration for enrollment.

EECS 31L. Introduction to Digital Logic Laboratory. 3 Units.
Introduction to common digital integrated circuits: gates, memory circuits, MSI components. Operating characteristics, specifications, applications. Design of simple combinational and sequential digital systems (arithmetic processors game-playing machines). Construction and debugging techniques using hardware description languages and CAD tools.

(Design units: 3)
Prerequisite: EECS 31 and (EECS 10 or EECS 12 or I&C SCI 32)
Restriction: Computer Science Engineering Majors have first consideration for enrollment. Electrical Engineering Majors have first consideration for enrollment. Computer Engineering Majors have first consideration for enrollment.

EECS 40. Object-Oriented Systems and Programming. 4 Units.

(Design units: 2)
Prerequisite: EECS 22L
Restriction: Computer Engineering Majors have first consideration for enrollment.

EECS 50. Discrete-Time Signals and Systems. 4 Units.
Analysis of discrete-time linear-time-invariant (DTLTI) systems in the time domain and using z-transforms. Introduction to techniques based on Discrete-Time, Discrete, and Fast Fourier Transforms. Examples of their application to digital signal processing and digital communications.

(Design units: 0)
Prerequisite: EECS 70A
Restriction: Computer Science Engineering Majors have first consideration for enrollment. Electrical Engineering Majors have first consideration for enrollment. Computer Engineering Majors have first consideration for enrollment.
EECS 55. Engineering Probability. 4 Units.
Sets and set operations; nature of probability, sample spaces, fields of events, probability measures; conditional probability, independence, random variables, distribution functions, density functions, conditional distributions and densities; moments, characteristic functions, random sequences, independent and Markov sequences.

(Design units: 0)
Prerequisite: MATH 2D
Restriction: Computer Engineering Majors have first consideration for enrollment. Electrical Engineering Majors have first consideration for enrollment.

EECS 70A. Network Analysis I. 4 Units.

(Design units: 1)
Corequisite: MATH 3D
Prerequisite: PHYSICS 7D and (EECS 10 or EECS 12 or ENGRMAE 10 or I&C SCI 31)
Overlaps with ENGRMAE 60.
Restriction: Computer Science Engineering Majors have first consideration for enrollment. Electrical Engineering Majors have first consideration for enrollment. Mechanical Engineering Majors have first consideration for enrollment. Aerospace Engineering Majors have first consideration for enrollment. Civil Engineering Majors have first consideration for enrollment. Computer Engineering Majors have first consideration for enrollment. Materials Science Engineering Majors have first consideration for enrollment. Environmental Engineering Majors have first consideration for enrollment.

EECS 70B. Network Analysis II. 4 Units.

(Design units: 1)
Corequisite: EECS 70LB
Prerequisite: (BME 60B or EECS 10 or EECS 12 or I&C SCI 31 or ENGRCEE 20 or ENGRMAE 10) and EECS 70A
Restriction: Electrical Engineering Majors have first consideration for enrollment. Computer Engineering Majors have first consideration for enrollment. Materials Science Engineering Majors have first consideration for enrollment.

EECS 70LA. Network Analysis I Laboratory. 1 Unit.
Laboratory to accompany EECS 70A.

(Design units: 0)
Corequisite: EECS 70A
Prerequisite: PHYSICS 7D and EECS 10

EECS 70LB. Network Analysis II Laboratory. 1 Unit.
Laboratory to accompany EECS 70B. Materials fee.

(Design units: 1)
Corequisite: EECS 70B
Prerequisite: (BME 60B or EECS 10 or EECS 12 or I&C SCI 31 or ENGRCEE 20 or ENGRMAE 10) and EECS 70A
Restriction: Electrical Engineering Majors have first consideration for enrollment. Computer Engineering Majors have first consideration for enrollment.

EECS 101. Introduction to Machine Vision. 3 Units.
The use of digital computers for the analysis of visual scenes; image formation and sensing, color, segmentation, shape estimation, motion, stereo, pattern classification, computer architectures, applications. Computer experiments are used to illustrate fundamental principles.

(Design units: 2)
Prerequisite: EECS 150 or EECS 50
Restriction: Electrical Engineering Majors have first consideration for enrollment. Computer Engineering Majors have first consideration for enrollment.
EECS 111. System Software. 4 Units.
Multiprogramming, interrupt, processes, kernel, parallelism, critical sections, deadlocks, communication, multiprocessing, multilevel memory management, binding, name management, file systems, protection, resource allocation, scheduling. Experience with concurrent programming, synchronization mechanisms, interprocess communication.

(Design units: 2)
Prerequisite: EECS 112 and (I&C SCI 46 or EECS 114)

Overlaps with COMPSCI 143A.

Restriction: Computer Science Engineering Majors have first consideration for enrollment. Computer Engineering Majors have first consideration for enrollment.

EECS 112. Organization of Digital Computers. 4 Units.
Building blocks and organization of digital computers, the arithmetic, control, and memory units, and input/output devices and interfaces. Microprogramming and microprocessors.

(Design units: 4)
Prerequisite: EECS 31L

Overlaps with COMPSCI 152.

Restriction: Computer Science Engineering Majors have first consideration for enrollment. Electrical Engineering Majors have first consideration for enrollment. Computer Engineering Majors have first consideration for enrollment.

EECS 112L. Organization of Digital Computers Laboratory. 3 Units.
Specification and implementation of a processor-based system using a hardware description language such as VHDL. Hands-on experience with design tools including simulation, synthesis, and evaluation using testbenches.

(Design units: 3)
Prerequisite: EECS 112

Restriction: Computer Science Engineering Majors have first consideration for enrollment. Computer Engineering Majors have first consideration for enrollment.

EECS 113. Processor Hardware/Software Interfaces. 4 Units.
Hardware/software interfacing, including memory and bus interfaces, devices, I/O, and compiler code generation/instruction scheduling. Experience microcontroller programming and interfacing. Specific compiler code generation techniques including local variable and register allocations, instruction dependence and scheduling, and code optimization.

(Design units: 3)
Prerequisite: EECS 112

Restriction: Computer Engineering Majors have first consideration for enrollment.

EECS 114. Engineering Data Structures and Algorithms. 4 Units.
Introduces abstract behavior of classes data structures, alternative implementations, informal analysis of time and space efficiency. Also introduces classic algorithms and efficient algorithm design techniques (recursion, divide-and-conquer, branch-and-bound, dynamic programming).

(Design units: 2)
Prerequisite: EECS 40

Restriction: Computer Engineering Majors have first consideration for enrollment.
EECS 116. Introduction to Data Management. 4 Units.
Introduction to the design of databases and the use of database management systems (DBMS) for applications. Topics include entity-relationship modeling for design, relational data model, relational algebra, relational design theory, and Structured Query Language (SQL) programming.

(Design units: 1)
Prerequisite: I&C SCI 33 or CSE 43 or EECS 114. I&C SCI 33 with a grade of C or better. CSE 43 with a grade of C or better
Same as COMPSCI 122A.
Restriction: Computer Science Engineering Majors have first consideration for enrollment. School of Info & Computer Sci students have first consideration for enrollment.

EECS 117. Parallel Computer Systems. 4 Units.
Fundamentals of parallel computing with designing, analyzing, implementing parallel algorithms on HPC architectures. Parallel models: work-depth, I/O memory models. Parallel architectures: shared-memory machines, distributed-memory machines, vector processors. Parallel algorithms and programming models for each machine type are discussed.

(Design units: 1)
Prerequisite: EECS 20 and EECS 114 and EECS 112
Restriction: Computer Engineering Majors have first consideration for enrollment.

EECS 118. Introduction to Knowledge and Software Engineering. 4 Units.
Introduction of basic concepts in knowledge engineering and software engineering. Knowledge representation and reasoning, search planning, software life cycle, requirements engineering, software design languages, declarative programming, testing, database and web programming.

(Design units: 2)
Prerequisite: EECS 40
Restriction: Computer Engineering Majors have first consideration for enrollment.

EECS 119. VLSI. 4 Units.
Design techniques for Very Large Scale Integrated (VLSI) systems and chips. Review CMOS and related process technologies; primitives such as logic gates and larger design blocks; layout; floor planning; design hierarchy, component interfaces; use of associated CAD tools for design.

(Design units: 4)
Prerequisite: EECS 112 and EECS 170B
Overlaps with EECS 170D, CSE 112.
Restriction: Computer Engineering Majors have first consideration for enrollment.

EECS 141A. Communication Systems I. 3 Units.
Introduction to analog communication systems including effects of noise. Modulation-demodulation for AM, DSB-SC, SSB, VSB, QAM, FM, PM, and PCM with application to radio, television, and telephony. Signal processing as applied to communication systems.

(Design units: 1)
Prerequisite: EECS 55 and EECS 150
Restriction: Computer Engineering Majors have first consideration for enrollment. Electrical Engineering Majors have first consideration for enrollment. Computer Science Engineering Majors have first consideration for enrollment.

EECS 141B. Communication Systems II. 3 Units.

(Design units: 1)
Prerequisite: EECS 141A
Restriction: Computer Engineering Majors have first consideration for enrollment. Electrical Engineering Majors have first consideration for enrollment. Computer Science Engineering Majors have first consideration for enrollment.
EECS 144. Antenna Design for Wireless Communication Links. 4 Units.

(Design units: 0)
Prerequisite: EECS 180A

EECS 145. Electrical Engineering Analysis. 4 Units.
Vector calculus, complex functions and linear algebra with applications to electrical engineering problems.

(Design units: 0)
Prerequisite: MATH 3D

Restriction: Computer Engineering Majors have first consideration for enrollment. Electrical Engineering Majors have first consideration for enrollment.

EECS 148. Computer Networks. 4 Units.
Computer network architectures, protocols, and applications. Internet congestion control, addressing, and routing. Local area networks. Multimedia networking.

(Design units: 2)
Prerequisite: EECS 55 or STATS 67

Same as COMPSCI 132.

Restriction: Computer Engineering Majors have first consideration for enrollment. Computer Science Engineering Majors have first consideration for enrollment.

EECS 150. Continuous-Time Signals and Systems. 4 Units.
Characteristics and properties of continuous-time (analog) signals and systems. Analysis of linear time-invariant continuous-time systems using differential equation convolutional models. Analysis of these systems using Laplace transforms, Fourier series, and Fourier transforms. Examples from applications to telecommunications.

(Design units: 0)
Prerequisite: EECS 70A and EECS 145

Restriction: Electrical Engineering Majors have first consideration for enrollment. Computer Engineering Majors have first consideration for enrollment.

EECS 152A. Digital Signal Processing. 3 Units.
Nature of sampled data, sampling theorem, difference equations, data holds, z-transform, w-transform, digital filters, Butterworth and Chebychev filters, quantization effects.

(Design units: 2)
Prerequisite: EECS 50

Restriction: Computer Science Engineering Majors have first consideration for enrollment. Electrical Engineering Majors have first consideration for enrollment. Computer Engineering Majors have first consideration for enrollment.

EECS 152B. Digital Signal Processing Design and Laboratory. 3 Units.
Design and implementation of algorithms on a DSP processor and using computer simulation. Applications in signal and image processing, communications, radar, etc.

(Design units: 3)
Prerequisite: (EECS 22 or I&C SCI 45C) and EECS 152A

Restriction: Computer Science Engineering Majors have first consideration for enrollment. Electrical Engineering Majors have first consideration for enrollment. Computer Engineering Majors have first consideration for enrollment.
EECS 159A. Senior Design Project I. 3 Units.
Teaches problem definition, detailed design, integration, and testability with teams of students specifying, designing, building, and testing complex systems. Lectures include engineering values, discussions, and ethical ramifications of engineering decisions.

(Design units: 3)
Prerequisite: EECS 113 or EECS 170C or COMPSCI 145
Restriction: Seniors only. Computer Science Engineering Majors only. Electrical Engineering Majors only. Computer Engineering Majors only.

EECS 159B. Senior Design Project II. 3 Units.
Teaches problem definition, detailed design, integration, and testability with teams of students specifying, designing, building, and testing complex systems. Lectures include engineering values, discussions, and ethical ramifications of engineering decisions.

(Design units: 3)
Prerequisite: EECS 159A
Restriction: Computer Science Engineering Majors only. Electrical Engineering Majors only. Computer Engineering Majors only.

EECS 160A. Introduction to Control Systems. 4 Units.
Modeling, stability, and specifications of feedback control systems. Root locus, Bode plots, Nyquist criteria, and state-space methods for dynamic analysis and design.

(Design units: 2)
Corequisite: EECS 160LA
Prerequisite: (EECS 10 or ENGRMAE 10) and EECS 150 and EECS 170B and EECS 170LB
Restriction: Electrical Engineering Majors have first consideration for enrollment.

EECS 160LA. Control Systems I Laboratory. 1 Unit.
Laboratory accompanying EECS 160A. Materials fee.

(Design units: 1)
Corequisite: EECS 160A
Restriction: Electrical Engineering Majors have first consideration for enrollment.

EECS 163. Power Systems. 4 Units.
Generation, transmission, and use of electrical energy. Fault calculation, protection, stability, and power flow.

(Design units: 1)
Corequisite: EECS 163L
Prerequisite: EECS 70B
Restriction: Electrical Engineering Majors have first consideration for enrollment.

EECS 163L. Power Systems Laboratory. 1 Unit.
Experiments and field trips relevant to studies in power systems. Materials fee.

(Design units: 0)
Corequisite: EECS 163
Restriction: Electrical Engineering Majors have first consideration for enrollment.

EECS 166A. Industrial and Power Electronics. 4 Units.
Power switching devices, pulse width modulation (PWM) methods, switching converter topologies, control, and magnetics. Materials fee.

(Design units: 2)
Prerequisite: EECS 170C and EECS 160A
Restriction: Electrical Engineering Majors have first consideration for enrollment.
Concurrent with EECS 267A.
EECS 170A. Electronics I. 4 Units.
The properties of semiconductors, electronic conduction in solids, the physics and operation principles of semiconductor devices such as diodes and transistors, transistor equivalent circuits, and transistor amplifiers.

(Design units: 1)
Corequisite: PHYSICS 7E
Prerequisite: PHYSICS 7D and EECS 70A
Restriction: Computer Engineering Majors have first consideration for enrollment. Electrical Engineering Majors have first consideration for enrollment.

EECS 170B. Electronics II. 4 Units.
Design and analysis of single-stage amplifiers, biasing circuits, inverters, logic gates, and memory elements based on CMOS transistors.

(Design units: 2)
Corequisite: EECS 170LB
Prerequisite: EECS 70B and EECS 170A and EECS 170LA
Restriction: Computer Engineering Majors have first consideration for enrollment. Electrical Engineering Majors have first consideration for enrollment. Materials Science Engineering Majors have first consideration for enrollment.

EECS 170C. Electronics III. 4 Units.
Principles of operation, design, and utilization of integrated circuit modules, including multi-stage amplifiers, operational amplifiers and logic circuits.

(Design units: 2)
Corequisite: EECS 170LC
Prerequisite: EECS 170B and EECS 170LB
Restriction: Electrical Engineering Majors have first consideration for enrollment.

EECS 170D. Integrated Electronic Circuit Design. 4 Units.
Design and fabrication of modern digital integrated circuits. Fabrication of CMOS process, transistor-level design simulation, functional characteristics of basic digital integrated circuits, and different logic families including the static and dynamic logic, layout, and extraction of digital circuits.

(Design units: 4)
Prerequisite: EECS 170C and EECS 170LC
Overlaps with EECS 119, CSE 112.
Restriction: Electrical Engineering Majors have first consideration for enrollment. Computer Engineering Majors have first consideration for enrollment.

EECS 170E. Analog and Communications IC Design. 4 Units.
Advanced topics in design of analog and communications integrated circuits. Topics include: implementation of passive components in integrated circuits; overview of frequency response of amplifiers, bandwidth estimation techniques, high-frequency amplifier design; design of radio-frequency oscillators.

(Design units: 3)
Prerequisite: EECS 170C

EECS 170LA. Electronics I Laboratory. 1 Unit.
Laboratory accompanying EECS 170A to perform experiments on semiconductor material properties, semiconductor device physics and operation principles, and transistor amplifiers to improve experimental skills and to enhance the understanding of lecture materials.

(Design units: 1)
Corequisite: EECS 170A and PHYSICS 7E
Prerequisite: PHYSICS 7D and EECS 70B
Restriction: Computer Engineering Majors have first consideration for enrollment. Electrical Engineering Majors have first consideration for enrollment. Materials Science Engineering Majors have first consideration for enrollment.
EECS 170LB. Electronics II Laboratory. 1 Unit.
Laboratory accompanying EECS 170B.

(Design units: 1)
Corequisite: EECS 170B
Prerequisite: EECS 170A and EECS 170LA
Restriction: Computer Engineering Majors have first consideration for enrollment. Electrical Engineering Majors have first consideration for enrollment.

EECS 170LC. Electronics III Laboratory. 1 Unit.
Laboratory accompanying EECS 170C to provide hands-on training in design of digital/analog circuits/subsystems. Materials fee.

(Design units: 1)
Corequisite: EECS 170C
Prerequisite: EECS 170B and EECS 170LB
Restriction: Electrical Engineering Majors have first consideration for enrollment.

EECS 174. Semiconductor Devices. 4 Units.
Metal-semiconductor junctions, diodes, bipolar junction transistors, MOS structures, MOSFETs, CMOS technology, LEDs, and laser diodes.

(Design units: 1)
Prerequisite: EECS 170A
Restriction: Electrical Engineering Majors have first consideration for enrollment. Materials Science Engineering Majors have first consideration for enrollment.

EECS 176. Fundamentals of Solid-State Electronics and Materials. 4 Units.
Physical properties of semiconductors and the roles materials play in device operation. Topics include: crystal structure, phonon vibrations, energy band, transport phenomenon, optical properties and quantum confinement effect essential to the understanding of electronic, optoelectronic and nanodevices.

(Design units: 1)
Prerequisite: EECS 170A
Restriction: Electrical Engineering Majors have first consideration for enrollment. Materials Science Engineering Majors have first consideration for enrollment.

EECS 179. Microelectromechanical Systems (MEMS). 4 Units.
Small-scale machines, small-scale phenomena, MEMS fabrication, MEMS CAD tools, MEMS devices and packaging, MEMS testing.

(Design units: 2)
Restriction: Upper-division students only. Electrical Engineering Majors have first consideration for enrollment. Biomedical Engineering Majors have first consideration for enrollment.

EECS 180A. Engineering Electromagnetics I. 4 Units.
Electrostatics, magnetostatics, and electromagnetic fields: solutions to problems in engineering applications; transmission lines, Maxwell's equations and phasors, plane wave propagation, reflection, and transmission. Formerly EECS 180.

(Design units: 1)
Corequisite: MATH 2D and MATH 3D
Prerequisite: PHYSICS 7E and EECS 145
Restriction: Biomedical Engineering Majors have first consideration for enrollment. Electrical Engineering Majors have first consideration for enrollment. Materials Science Engineering Majors have first consideration for enrollment.
EECS 180B. Engineering Electromagnetics II. 4 Units.
Time-varying electromagnetic fields, plane waves, polarization, guidance of waves like rectangular waveguides and microstrips, optical fibers resonant cavities, skin effects and losses, spherical waves, radiation and reception of waves, antenna basics. Formerly EECS 187.

(Design units: 1)
Prerequisite: EECS 180A
Restriction: Electrical Engineering Majors have first consideration for enrollment.

EECS 180C. Engineering Electromagnetics III. 4 Units.

(Design units: 0)
Prerequisite: EECS 180B
Restriction: Electrical Engineering Majors have first consideration for enrollment.

EECS 182. Monolithic Microwave Integrated Circuit (MMIC) Analysis and Design. 4 Units.
Design of microwave amplifiers including low-noise amplifiers, multiple stage amplifiers, power amplifiers, and introduction to broadband amplifiers. The goal is to provide the basic knowledge for the design of microwave amplifiers ranging from wireless system to radar system.

(Design units: 3)
Prerequisite: EECS 180A

EECS 188. Optical Electronics. 4 Units.
Photodiodes and optical detection, photometry and radiometry, geometric optics, lens theory, imaging system, EM wave propagation, optical waveguides and fibers, heterojunction structures, laser theory, semiconductor lasers, and optical transmission system.

(Design units: 1)
Prerequisite: EECS 180A
Restriction: Electrical Engineering Majors have first consideration for enrollment.

EECS 195. Special Topics in Electrical and Computer Engineering. 1-4 Units.
Studies special topics in selected areas of Electrical and Computer Engineering. Topics addressed vary each quarter.

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

EECS 198. Group Study. 1-4 Units.
Group study of selected topics in Electrical and Computer Engineering.

(Design units: 1-4)
Repeatability: May be repeated for credit unlimited times.
Restriction: Upper-division students only.

EECS 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.
EECS 199P. 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 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.

EECS 202A. Principles of Imaging. 4 Units.
Linear systems, probability and random processes, image processing, projecting imaging, tomographic imaging.

Same as PHYSICS 233A.

Restriction: Graduate students only.

Concurrent with PHYSICS 147A.

EECS 202B. Techniques in Medical Imaging I: X-ray, Nuclear, and NMR Imaging. 4 Units.
Ionizing radiation, planar and tomographic radiographic and nuclear imaging, magnetism, NMR, MRI imaging.

Prerequisite: EECS 202A

Same as PHYSICS 233B.

Restriction: Graduate students only.

Concurrent with PHYSICS 147B.

EECS 202C. Techniques in Medical Imaging II: Ultrasound, Electrophysiological, Optical. 4 Units.
Sound and ultrasound, ultrasonic imaging, physiological electromagnetism, EEG, MEG, ECG, MCG, optical properties of tissues, fluorescence and bioluminescence, MR impedance imaging, MR spectroscopy, electron spin resonance and ESR imaging.

Prerequisite: EECS 202B

Same as PHYSICS 233C.

Restriction: Graduate students only.

Concurrent with PHYSICS 147C.

EECS 203A. Digital Image Processing. 4 Units.
Pixel-level digital image representation and elementary operations; Fourier and other unitary transforms; compression, enhancement, filtering, and restoration; laboratory experience is provided.

Restriction: Graduate students only.

EECS 211. Advanced System Software. 4 Units.
Study of operating systems including interprocess communication, scheduling, resource management, concurrency, reliability, validation, protection and security, and distributed computing support. System software design languages and modeling analysis.

Restriction: Graduate students only.

EECS 213. Computer Architecture. 4 Units.
Problems in hardware, firmware (microprogram), and software. Computer architecture for resource sharing, real-time applications, parallelism, microprogramming, and fault tolerance. Various architectures based on cost/performance and current technology.

Restriction: Graduate students only.

EECS 215. Design and Analysis of Algorithms. 4 Units.
Computer algorithms from a practical standpoint. Algorithms for symbolic and numeric problems such as sorting, searching, graphs, and network flow. Analysis includes algorithm time and space complexity.
EECS 217. VLSI System Design. 4 Units.
Overview of integrated fabrication, circuit simulation, basic device physics, device layout, timing; MOS logic design; layout generation, module generation, techniques for very large scale integrated circuit design.

Restriction: Graduate students only.

EECS 219. Distributed Software Architecture and Design. 4 Units.
Practical issues for reducing the software complexity, lowering cost, and designing and implementing distributed software applications. Topics include the distributed object model distributed environment, platform-independent software agents and components, the middleware architecture for distributed real-time and secure services.

Prerequisite: EECS 211

Restriction: Graduate students only.

EECS 220. Advanced Digital Signal Processing Architecture. 4 Units.
Study the latest DSP architectures for applications in communication (wired and wireless) and multimedia processing. Emphasis given to understanding the current design techniques and to evaluate the performance, power, and application domain of the latest DSP processors.

Prerequisite: EECS 213

Restriction: Graduate students only.

EECS 221. Topics in Computer Engineering. 4 Units.
New research results in computer engineering.

Repeatability: Unlimited as topics vary.

Restriction: Graduate students only.

EECS 222. Embedded System Modeling. 4 Units.
Computational models for embedded systems. System-level specification and description languages. Concepts, requirements, examples. Embedded system models at different levels of abstraction. Modeling of test benches, design under test, IP components. Discrete event simulation, semantics, and algorithms. Formerly EECS 222A.

Restriction: Graduate students only.

EECS 223. Real-Time Computer Systems. 4 Units.
Time bases, clock synchronization, real-time communication protocols, specification of requirements, task scheduling. Validation of timelines, real-time configuration management.

Prerequisite: EECS 211 and EECS 213

Restriction: Graduate students only.

EECS 224. High-Performance Computing. 4 Units.
Fundamentals of high-performance computing, covering both theory and practice. Topics include performance analysis and tuning, design of parallel and I/O efficient algorithms, basics of parallel machine architectures, and current/emerging programming models (shared memory, distributed memory, and accelerators).

Prerequisite: EECS 215 or COMPSCI 260

Restriction: Graduate students only.

EECS 225. Embedded Systems Design. 4 Units.
Embedded systems design flow and methodology. Design space exploration. Co-design of hardware and software, embedded architecture and network exploration and synthesis. System software/hardware interface generation. Real-time constraints, specification-to-architecture mapping, design tools and methodologies. Formerly EECS 222B.

Restriction: Graduate students only.

EECS 226. Embedded System Software. 4 Units.
Embedded system software concepts, requirements, examples, for engineering applications such as multi-media and automotive. Software generation methodology. Algorithmic specification, design constraints. Embedded operating systems. Static, dynamic, real-time scheduling. Input/output, interrupt handling. Code generation, compilation, instruction set simulation. Formerly EECS 222C.

Restriction: Graduate students only.
EECS 227. Cyber-Physical System Design. 4 Units.
Model-based design of cyber-physical systems including, e.g., plant, sensing, control, actuation, embedded hardware/software, communication, real-time analysis, various levels of simulation (MILS, SILS, HILS), tools and methodologies for automatic synthesis, and application from various interdisciplinary domains.

Restriction: Graduate students only.

EECS 228. Program Analysis. 4 Units.
Advance study of programming languages, compilers, and interpreters. Static and dynamic program analysis and its use in compilation, optimization, garbage collection, bug finding, and parallelization.

Prerequisite: EECS 215 or COMPSCI 260

Restriction: Graduate students only.

EECS 229. Low Power SoC Design. 4 Units.
From an inverter to server centers, low-power design theory and practice in modern systems-on-chip (SoC), energy efficient design time and runtime methods are surveyed at circuit, RTL, and architecture levels. Lab assignments will help students quantify tradeoffs and design practices.

Prerequisite: EECS 217

Restriction: Graduate students only.

EECS 230. Energy Efficiency. 4 Units.
Green energy sources for production, transmission, storage, and utilization of electricity, with a special focus on solar, wind, and nuclear energy production. Study of newly developed renewable sources of energy including capital cost, product cost, environmental issues, and technical feasibility.

EECS 240. Random Processes. 4 Units.

Restriction: Graduate students only.

EECS 241A. Digital Communications I. 4 Units.
Concepts and applications of digital communication systems. Baseband digital transmission of binary, multi-amplitude, and multidimensional signals. Introduction to and performance analysis of different modulation schemes.

EECS 241B. Digital Communications II. 4 Units.
Concepts and applications of equalization, multi-carrier modulation, spread spectrum and CDMA. Digital communications through fading memory channels.

Prerequisite: EECS 241A

Restriction: Graduate students only.

EECS 242. Information Theory. 4 Units.
Fundamental capabilities and limitations of information sources and information transmission systems. Analytical framework for modeling and evaluating communication systems: entropy, mutual information asymptotic equipartition property, entropy rates of a stochastic process, data compression, channel capacity, differential entropy, the Gaussian channel.

Prerequisite: EECS 240

EECS 243. Error Correcting Codes. 4 Units.
Different techniques for error correcting codes and analyzing their performance. Linear block codes; cyclic codes; convolutional codes. Minimum distance; optimal decoding; Viterbi decoding; bit error probability. Coding gain; trellis coded modulation.

Prerequisite: EECS 240

Restriction: Graduate students only.
EECS 244. Wireless Communications. 4 Units.

Prerequisite: EECS 241B
Restriction: Graduate students only.

EECS 245. Space-Time Coding. 4 Units.
A fundamental study of: Capacity of MIMO Channels, space-time code design criteria, space-time block codes, space-time trellis codes, differential detection for multiple antennas, spatial multiplexing, BLAST.

Prerequisite: EECS 242
Restriction: Graduate students only.

EECS 247. Information Storage. 4 Units.
Storage architecture, storage network and networking algorithms in data centers, principle of storage devices and non-volatile memory, data consistency, data availability and integrity, power management.

Restriction: Graduate students only.

EECS 248A. Computer and Communication Networks. 4 Units.

Prerequisite: EECS 148 or COMPSCI 132
Same as COMPSCI 232, NET SYS 201.
Restriction: Graduate students only.

EECS 250. Digital Signal Processing I. 4 Units.
Fundamental principles of digital signal processing, sampling, decimation and interpolation, discrete Fourier transforms and FFT algorithms, transversal and recursive filters, discrete random processes, and finite-word effects in digital filters.

Restriction: Graduate students only.

EECS 251A. Detection, Estimation, and Demodulation Theory. 4 Units.

Prerequisite: EECS 240

EECS 251B. Detection, Estimation, and Demodulation Theory. 4 Units.

Prerequisite: EECS 240

EECS 260A. Linear Systems I. 4 Units.
State-space representation of continuous-time and discrete-time linear systems. Controllability, observability, stability. Realization of rational transfer functions.

Restriction: Graduate students only.

EECS 261A. Linear Optimization Methods. 4 Units.

Restriction: Graduate students only.
EECS 267A. Industrial and Power Electronics. 4 Units.
Power switching devices, pulse width modulation (PWM) methods, switching converter topologies, control, and magnetics. Materials fee.

Restriction: Graduate students only.

Concurrent with EECS 166A.

EECS 267B. Topics in Industrial and Power Electronics. 4 Units.
Practical design of switching converters, electromagnetic compatibility, thermal management, and/or control methods.

Prerequisite: EECS 267A

Restriction: Graduate students only.

EECS 270A. Advanced Analog Integrated Circuit Design I. 4 Units.
Basic transistor configurations; differential pairs; active load/current sources; supply/temperature-independent biasing; op-amp gain and output stages; amplifier frequency response and stability compensation; nonidealities in op-amps; noise and dynamic range in analog circuits.

Restriction: Graduate students only.

EECS 270B. Advanced Analog Integrated Circuit Design II. 4 Units.
Advanced transistor modeling issues; discrete-time and continuous-time analog Integrated Circuit (IC) filters; phase-locked loops; design of ICs operating at radio frequencies; low-voltage/low-power design techniques; A/D and D/A converters; AGC circuits.

Prerequisite: EECS 270A

Restriction: Graduate students only.

EECS 270C. Design of Integrated Circuits for Broadband Applications. 4 Units.
Topics include: broadband standards and protocols; high-frequency circuit design techniques; PLL theory and design; design of transceivers; electrical/optical interfaces.

Prerequisite: EECS 270A

Restriction: Graduate students only.

EECS 270D. Radio-Frequency Integrated Circuit Design. 4 Units.
Topics include: RF component modeling; matching network design; transmission line theory/modeling; Smith chart and S-parameters; noise modeling of active and passive components; high-frequency amplifier design; low-noise amplifier (LNA) design; mixer design; RF power amplifier.

Prerequisite: EECS 270A

Restriction: Graduate students only.

EECS 272. Topics in Electrical Engineering. 4 Units.
New research results in electronic system design.

Repeatability: Unlimited as topics vary.

Restriction: Graduate students only.

EECS 275A. Very Large Scale Integration (VLSI) Project. 4 Units.
Students create VLSI design projects from conception through architecture, floor planning, detailed design, simulation, verification, and submission for project fabrication. Emphasis on practical experience in robust VLSI design techniques. (Successful students are expected to take EECS 275B.)

Restriction: Graduate students only.

EECS 275B. Very Large Scale Integration (VLSI) Project Testing. 4 Units.
Test and document student-created Complementary Metal Oxide Semiconductor (CMOS) Very Large Scale Integration (VLSI) projects designed in EECS 275A. Emphasis on practical laboratory experience in VLSI testing techniques. Materials fee.

Prerequisite: EECS 275A

Restriction: Graduate students only.
EECS 277A. Advanced Semiconductor Devices I. 4 Units.
Advanced complementary metal-oxide-semiconductor field-effect transistors (CMOSFET), device scaling, device modeling and fabrication, equivalent circuits, and their applications for digital, analog, RF.
Restriction: Graduate students only.

EECS 277B. Advanced Semiconductor Devices II. 4 Units.
Metal-semiconductor field-effect transistors (MESFET), heterojunction bipolar transistors (HBT), microwave semiconductor devices, equivalent circuits, device modeling and fabrication, microwave amplifiers, transmitters, and receivers.
Restriction: Graduate students only.

EECS 277C. Nanotechnology. 4 Units.
Restriction: Graduate students only.

EECS 278. 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 ENGRMAE 247.
Restriction: Graduate students only.

EECS 279. 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 ENGRMAE 249.
Restriction: Graduate students only.

EECS 280A. Advanced Engineering Electromagnetics I. 4 Units.
Stationary electromagnetic fields, Maxwell's equations, circuits and transmission lines, plane waves, guided waves, and radiation.
Restriction: Graduate students only.

EECS 280B. Advanced Engineering Electromagnetics II. 4 Units.
Two- and three-dimensional boundary value problems, dielectric waveguides and other special waveguides, microwave networks and antenna arrays, electromagnetic properties of materials, and electromagnetic optics.
Prerequisite: EECS 280A
Restriction: Graduate students only.

EECS 282. Monolithic Microwave Integrated Circuit (MMIC) Analysis and Design II. 4 Units.
Design of microwave amplifiers using computer-aided design tools. Covers low-noise amplifiers, multiple stage amplifiers, broadband amplifiers, and power amplifiers. Hybrid circuit design techniques including filters and baluns. Theory and design rules for microwave oscillator design.
Restriction: Graduate students only.

EECS 285A. Optical Communications. 4 Units.
Introduction to fiber optic communication systems, optical and electro-optic materials, and high-speed optical modulation and switching devices.
Restriction: Graduate students only.

EECS 285B. Lasers and Photonics. 4 Units.
Covers the fundamentals of lasers and applications, including Gaussian beam propagation, interaction of optical radiation with matters, and concepts of optical gain and feedback. Applications are drawn from diverse fields of optical communication, signal processing, and material diagnosis.
Prerequisite: Undergraduate course work in electromagnetic theory and atomic physics.
EECS 285C. Nano Imaging. 4 Units.
Theory and practice of modern nanoscale imaging techniques and applications. Traces the development of microscopy from ancient times to modern day techniques used for visualizing the nano-world from atoms to molecules including hands-on experience in the laboratory.
Restriction: Graduate students only.

EECS 286. Biomedical and Wearable Microdevices. 4 Units.
Preliminary details on prototyping and fabrication techniques for biomedical and wearable microdevices. Behavior and properties of modern microdevice materials such as hydrogel, PDMS, biopolymer, smart materials, and their uses. Basic biosensing modalities and practical implementations in modern devices.
Prerequisite: Knowledge of undergraduate-level basic physics is required.
Restriction: Graduate students only.

EECS 290. Curricular Practical Training. 1 Unit.
Curricular practical training. Students will go through practical training under an industry mentor in a technical field corresponding to their concentration area.
Grading Option: Satisfactory/unsatisfactory only.
Repeatability: May be repeated for credit unlimited times.
Restriction: Graduate students only.

EECS 292. Preparation for M.S. Comprehensive Examination. 1-8 Units.
Individual reading and preparation for the M.S. comprehensive examination.
Grading Option: Satisfactory/unsatisfactory only.
Repeatability: May be repeated for credit unlimited times.
Restriction: Graduate students only.

EECS 293. Preparation for Ph.D. Preliminary Examination. 1-8 Units.
Individual reading and preparation for the Ph.D. preliminary examination.
Grading Option: Satisfactory/unsatisfactory only.
Repeatability: May be repeated for credit unlimited times.
Restriction: Graduate students only.

EECS 294. Electrical Engineering and Computer Science Colloquium. 1 Unit.
Invited speakers discuss their latest research results in electrical engineering and computer science.
Grading Option: Satisfactory/unsatisfactory only.
Repeatability: May be repeated for credit unlimited times.
Restriction: Graduate students only.

EECS 295. Seminars in Engineering. 1-4 Units.
Scheduled each year by individual faculty in major field of interest.
Grading Option: Satisfactory/unsatisfactory only.
Repeatability: Unlimited as topics vary.
Restriction: Graduate students only.

EECS 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. degree in Engineering.
Repeatability: May be repeated for credit unlimited times.
Restriction: Graduate students only.
EECS 297. Doctor of Philosophy Dissertation Research. 1-16 Units.
Individual research or investigation conducted in preparing and completing the dissertation required for the Ph.D. degree in Engineering.

Repeatability: May be repeated for credit unlimited times.

Restriction: Graduate students only.

EECS 298. Topics in Electrical Engineering and Computer Science. 4 Units.
Study of Electrical and Computer Engineering concepts.

Repeatability: Unlimited as topics vary.

Restriction: Graduate students only.

EECS 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: Graduate students only.

Engineering Courses

ENGR 1A. General Chemistry for Engineers. 4 Units.
Emphasis on solid-state chemistry. Quantum theory, atomic structure, periodic trends, chemical bonding, molecular orbitals, electronic band structure, gases, liquids, intermolecular forces, unit cells, crystal lattices, phase transformations, and electrochemistry.

(Design units: 0)

Prerequisite: A score of 2 or 3 on the AP Chemistry exam, or a score of 550 or higher on the SAT Chemistry Subject exam, or Engineering Chemistry Placement Exam (fee required).

Overlaps with CHEM 1A.

Restriction: School of Engineering students only.

ENGR 7A. Introduction to Engineering I. 2 Units.
Introduction to engineering disciplines and the design process. Course may be offered online. Materials fee.

(Design units: 1)

Grading Option: In progress only.

Restriction: Lower-division students only.

ENGR 7B. Introduction to Engineering II. 2 Units.
Introduction to engineering disciplines and the design process. Course may be offered online. Materials fee.

(Design units: 2)

Prerequisite: ENGR 7A

Restriction: Lower-division students only.

ENGR 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, ENGRMAE 30.

Restriction: School of Engineering students have first consideration for enrollment.
ENGR 54. Principles of Materials Science and Engineering. 4 Units.
Superconductors to biodegradable polymers. Structure and properties of materials, including metal, ceramics, polymers, semiconductors, composites, traditional materials. Atomic structure, bonding, defects, phase equilibria, mechanical properties, electrical, optical and magnetic properties. Introduction to materials processing and synthesis. Course may be offered online. Materials fee.

(Design units: 0)
Prerequisite: (ENGR 1A or CHEM 1A) and PHYSICS 7C
Restriction: School of Engineering students have first consideration for enrollment.

ENGR 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, ENGRMAE 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.

ENGR 92. Engineering and Computer Educational Laboratory. 1-4 Workload Units.
Comprehensive academic support designed primarily for underrepresented or underprepared students in Engineering, ICS, or selected areas of the physical sciences. Typical program activities: tutoring, study skills, career planning, self-esteem enhancement, library research techniques.

(Design units: 0)
Grading Option: Workload Credit P/NP Only.
Repeatability: May be taken for credit for 12 units.

ENGR 93. Public and Professional Service in Engineering. 1-2 Workload Units.
Student participation in public and professional service activities related to engineering.

(Design units: 0)
Grading Option: Workload Credit P/NP Only.
Repeatability: May be repeated for credit unlimited times.

ENGR 98. Group Study . 1-4 Units.
Group study of selected topics in engineering.

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

ENGR 100. Special Topics in Fabrication Safety. 1 Workload Unit.
Hands on training in the safe use of item fabrication: metalworking, woodworking, electronics fabrication, composites, welding, adhesives, water disposal, and others. Safety certification will be granted from this course and is required for access to Engineering School fabrication facilities.

(Design units: 0)
Repeatability: Unlimited as topics vary.
Restriction: School of Engineering students have first consideration for enrollment.
ENGR 150. Mechanics of Structures. 4 Units.

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

ENGR 165. Advanced Manufacturing. 4 Units.
Principles in manufacturing processes. All machining requires energy: mechanical (cutting and shaping), heat energy (laser cutting), photochemical (photolithography), chemical energy (electro chemical machining and chemical vapor deposition). These methods and their fundamentals are examined. Materials fee.

(Design units: 2)
Restriction: Seniors only. School of Engineering students only.
Concurrent with ENGR 265.

ENGR 180. Entrepreneurship for Scientists and Engineers. 4 Units.
Real-world introduction to the theory and practice of entrepreneurship. Explore organizational, strategic, and financial challenges; start-up strategies; business idea evaluation; and business plan writing. Presentations by prestigious entrepreneurs and industry leaders.

(Design units: 0)
Restriction: Upper-division students only. School of Engineering students have first consideration for enrollment.
Concurrent with ENGR 280.

ENGR 189. Senior Project - Topics Vary. 1-4 Units.
Multidisciplinary group senior project of theoretical or applied nature involving design.

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

ENGR 190W. Communications in the Professional World. 4 Units.
Upper-division technical writing course including the development of presentation skills. Effective communication with a range of audiences. Recognition of ethical and professional responsibilities for engineers.

(Design units: 0)
Prerequisite: Satisfactory completion of the Lower-Division Writing requirement.
Restriction: School of Engineering students only.

ENGR 195. Special Topics in Engineering. 1-4 Units.
Studies in selected areas of Engineering. Topics addressed vary each quarter.

(Design units: 1-4)
Prerequisite: Prerequisites vary.
Repeatability: Unlimited as topics vary.
ENGR 196W. Engineering Thesis. 4 Units.
Preparation of final presentation and paper describing individual research in Engineering completed in one or more quarters of individual study (i.e., ENGR 199).

(Design units: 0)

Prerequisite: Completion of at least 4 units of Individual Research in Engineering. Satisfactory completion of the Lower-Division Writing requirement.

( Ib)

ENGR H196W. Honors Thesis. 4 Units.
Preparation of final presentation and paper describing individual research in Engineering. For participants in the Campuswide Honors Program.

(Design units: 1-4)

Prerequisite: ENGR H199. Satisfactory completion of the Lower-Division Writing requirement.

Restriction: Campuswide Honors Program students only.

( Ib)

ENGR 197A. Educational Strategies for Tutoring and Teacher Aiding. 4 Units.
Placement in a public elementary or secondary school to gain experience as a tutor or teacher aide. Emphasis on cognitive learning and the development of instructional strategies and resources which can be used in effective cross-age and cross-cultural experiences.

Grading Option: Pass/no pass only.

Repeatability: May be taken for credit 3 times.

Same as EDUC 100.

Restriction: Pass/not-pass option only

ENGR 199. Individual Study. 1-4 Units.
Supervised independent reading, research, or design for undergraduate Engineering majors. 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.

Restriction: School of Engineering students only.

ENGR 199P. Individual Study. 1-4 Units.
Supervised independent reading, research, or design for undergraduate Engineering majors. 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)

Grading Option: Pass/no pass only.

Repeatability: May be repeated for credit unlimited times.

ENGR H199. Individual Study for Honors Students. 1-5 Units.
Supervised research in Engineering for participants in the Campuswide Honors Program. 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: 1-5)

Repeatability: May be repeated for credit unlimited times.

Restriction: Campuswide Honors Program students only.
ENGR 265. Advanced Manufacturing. 4 Units.
Principles in manufacturing processes. All machining requires energy: mechanical (cutting and shaping), heat energy (laser cutting), photochemical (photolithography), chemical energy (electro chemical machining and chemical vapor deposition). These methods and their fundamentals are examined. Materials fee.

Restriction: Graduate students only. School of Engineering students only.

Concurrent with ENGR 165.

ENGR 280. Entrepreneurship for Scientists and Engineers. 4 Units.
Real-world introduction to the theory and practice of entrepreneurship. Explore organizational, strategic, and financial challenges; start-up strategies; business idea evaluation; and business plan writing. Presentations by prestigious entrepreneurs and industry leaders.

Restriction: School of Engineering students have first consideration for enrollment. Graduate students only.

Concurrent with ENGR 180.

ENGR 295. Special Topics in Engineering. 1-4 Units.
Studies in selected areas of Engineering. Topics addressed vary each quarter.

Prerequisite: Prerequisites vary.

Repeatability: Unlimited as topics vary.

Restriction: Graduate students only.

ENGR 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.

ENGR 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.

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

Repeatability: May be repeated for credit unlimited times.

ENGR 399. University Teaching. 4 Units.
University teaching with Engineering faculty.

Grading Option: Satisfactory/unsatisfactory only.

Repeatability: May be repeated for credit unlimited times.

Restriction: Teaching assistants only.

Mechanical and Aerospace Engr Courses

ENGRMAE 10. Introduction to Engineering Computations. 4 Units.
Introduction to the solution of engineering problems through the use of the computer. Elementary programming in FORTRAN and Matlab is taught. No previous knowledge of computer programming is assumed.

(Design units: 1)

Corequisite: MATH 2A
Prerequisite: MATH 2A

Overlaps with EECS 10, EECS 12, BME 60B.

Restriction: School of Engineering students 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.

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. Materials Science 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 uncertainly 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: Chemical Engineering Majors have first consideration for enrollment. Environmental Engineering Majors have first consideration for enrollment. Mechanical 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 130B
Restriction: Aerospace Engineering Majors have first consideration for enrollment. Mechanical 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
Overlaps with CBEMS 45C, CBEMS 65B.
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 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
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. Mechanical 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)
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) and ENGRMAE 91. 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. 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. ENGRMAE 91 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 130B
Restriction: Aerospace Engineering Majors have first consideration for enrollment. Mechanical 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: Aerospace Engineering Majors have first consideration for enrollment. Biomedical Engineering Majors have first consideration for enrollment. Materials Science Engineering Majors have first consideration for enrollment. Mechanical 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.

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 CBEMS 155.

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

ENGRMAE 157. Lightweight Structures. 4 Units.
Fundamentals of torsion and bending. Analysis and design of thin-wall and composite beams. Stress analysis of aircraft components. Stiffness, strength,
and buckling. Introduction to the Finite Element method and its application to plates and shells.

(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

Restriction: Aerospace Engineering Majors have first consideration for enrollment. Mechanical 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 and (ENGRMAE 130A or ENGRCEE 170)

Restriction: Chemical Engineering Majors have first consideration for enrollment. Environmental Engineering Majors have first consideration for
enrollment. Mechanical 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
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 and MATH 3D and MATH 2E
Overlaps with MATH 105A.
Restriction: Civil Engineering Majors have first consideration for enrollment. Mechanical Engineering Majors have first consideration for enrollment.
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 heterogeneous reactions, with emphasis on kinetics, thermal ignition, turbulent flame propagation, 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.

ENGRMAE 238. Experimental Fluid Dynamics. 4 Units.

Prerequisite: ENGRMAE 230A and ENGRMAE 230B
Restriction: Graduate students only.

ENGRMAE 239. Dynamics of Unsteady Flows. 4 Units.

Prerequisite: ENGRMAE 230A is recommended.
Restriction: Graduate students only.

ENGRMAE 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.
ENGRMAE 242. Robotics. 4 Units.

Restriction: Graduate students only.

ENGRMAE 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.

ENGRMAE 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.

ENGRMAE 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.

ENGRMAE 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.

ENGRMAE 250. Biobotics. 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.

Concurrent with ENGRMAE 153.

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.
Concurrent with ENGRMAE 155.

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 Tropospheric and Stratospheric Processes. 4 Units.
Examination of current issues related to the atmosphere, including energy usage; toxicology; effects on humans, forests, plants, and ecosystems; particulate matter (PM10); combustion; modeling and meteorology; airborne toxic chemicals and risk assessment; application of science to development of 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