The Henry Samueli School of Engineering

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

With engineering as the driving force in economic areas such as health care, communications, and sustainability, it is critical to rethink what it means to be an engineer. While there has been strength in the conventional engineering disciplines for centuries, today's global complexity is placing new demands on how we live, learn, and work. With this in mind, our strategic plan for the Samueli School places leadership and innovation as foundational elements for educating tomorrow's engineers.

The academic mission of the Samueli School is to advance engineering discovery through the creation of original scholarship and research applied to societal grand challenges, to educate and train the next generation of global innovators, and to provide a technological edge to industry by facilitating technology transfer and talent acquisition. The school includes six academic departments: biomedical engineering; chemical and biomolecular engineering; civil and environmental engineering; electrical engineering and computer science; materials science and engineering; and mechanical and aerospace engineering.

We offer undergraduate degrees in a wide range of traditional and emerging fields. Students have choices and can take advantage of the many opportunities available to them. The first year of study for each engineering major is similar, designed to allow exploration of the foundations of engineering and selection of a program that best fits each student's individual interests.

All engineering programs combine science, engineering fundamentals, design principles and application, and a culminating design experience. Students are encouraged to participate in research and hands-on engineering design opportunities to develop the practical skills needed for graduate study or employment.

The school is also committed to increasing diversity in engineering. The Office of Access and Inclusion supports the recruitment, retention, and graduation of undergraduate and graduate students from populations underrepresented in engineering.

The Samueli School's faculty members are leaders in their disciplines who have achieved worldwide recognition for their research and dedicated teaching. Faculty quality has remained high while increasing steadily in number and diversity over the past few years, giving students a remarkable range of expertise in engineering and with it, a large number of different advanced courses and research opportunities.

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), Environmental Engineering (EnE), Materials Science and Engineering (MSE), and Mechanical Engineering (ME). The undergraduate majors in Aerospace, Biomedical, Chemical, Civil, Computer, Computer Science and Engineering, Electrical, Environmental, Materials Science and Engineering, 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.

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

Materials Science and 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 and 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 and 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 and 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 Biomolecular Engineering; Civil and Environmental Engineering; Electrical and Computer Engineering, with concentrations in Computer Engineering and Electrical Engineering; Engineering, with a concentration in 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 biomedical computational technologies, biomedical nanoscale systems, biophotonics, biomolecular/genetic engineering, tissue engineering, cardiovascular engineering, and neuroengineering. Bioreaction and bioreactor engineering, recombinant cell technology, and bioseparation processes are research areas in Chemical and Biomolecular Engineering. In Civil and Environmental Engineering, research opportunities are provided in structural/earthquake engineering, reliability engineering, transportation systems engineering, environmental and energy, and water resources. Research opportunities in Electrical Engineering and Computer Science 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.

Additional information about undergraduate and graduate academic study and research opportunities are available through the Samueli School of Engineering website (engineering.uci.edu), and directly from the Departments of Biomedical Engineering, Chemical and Biomolecular Engineering, Civil and Environmental Engineering, Electrical Engineering and Computer Science, Materials Science and Engineering, and Mechanical and Aerospace Engineering.

- Department of Biomedical Engineering
- Department of Chemical and Biomolecular Engineering
- Department of Civil and Environmental Engineering
- Department of Electrical Engineering and Computer Science

- Department of Materials Science and Engineering
- Department of Mechanical and Aerospace Engineering

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 (http://catalogue.uci.edu/informationforadmittedstudents/requirementsforabachelorsdegree/).

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: Some 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 have a hold placed on their enrollment for the upcoming term.

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 via http://undergraduate.eng.uci.edu/forms. (http://undergraduate.eng.uci.edu/forms/)

- Aerospace Engineering, B.S.
- Biomedical Engineering, B.S.
- Biomedical Engineering, M.S.
- Biomedical Engineering, Minor
- Biomedical Engineering, Ph.D.
- Biomedical Engineering: Premedical, B.S.
- Biotechnology Management, M.S.
- Chemical and Biomolecular Engineering, M.S.
- Chemical and Biomolecular Engineering, Ph.D.
- Chemical Engineering, B.S.
- Civil and Environmental Engineering, M.S.
- Civil and Environmental Engineering, Ph.D.
- Civil Engineering, B.S.
- Computational Science, Ph.D.
- Computer Engineering, B.S.
- Computer Science and Engineering, B.S.
- Electrical and Computer Engineering, M.S.
- Electrical and Computer Engineering, Ph.D.
- Electrical Engineering, B.S.
- Engineering Management, M.S.
- Engineering, M.S. (Concentration in Materials and Manufacturing Technology)
- Engineering, Ph.D. (Concentration in Materials and Manufacturing Technology)

- Environmental Engineering, B.S.
- Master of Embedded and Cyber-Physical Systems
- Master of Engineering
- Materials Science and Engineering, B.S.
- Materials Science and Engineering, M.S.
- Materials Science and Engineering, Minor
- Materials Science and Engineering, Ph.D.
- Mechanical and Aerospace Engineering, M.S.
- Mechanical and Aerospace Engineering, Ph.D.
- Mechanical Engineering, B.S.
- Networked Systems, M.S.
- Networked Systems, Ph.D.

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

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, 2023, must have submitted their completed application during the priority filing period (November 1 - November 30, 2022).

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.

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. IGETC 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 Undergraduate Admissions, 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 with fewer than 90 units 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. Interested students must attend a change of major workshop. Information is also available at the UCI Change of Major Criteria website (http://www.changeofmajor.uci.edu/). Change of major requests for those students with 90 or more units will be decided on a case-by-case basis.

Engineering Undeclared 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 Undeclared Curriculum and follow the Sample Engineering Undeclared Curriculum. Students following the Engineering Undeclared 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 Undeclared Curriculum - Freshman [1]

Freshman		
Fall	**Winter**	**Spring**
MATH 2A	MATH 2B	MATH 2D
ENGR 7A	ENGR 7B	PHYSICS 7D
ENGR 1A or CHEM 1A	CHEM 1B	PHYSICS 7LD
Select one of the following:	PHYSICS 7C	Select one of the following:
EECS 10	PHYSICS 7LC	CHEM 1C- 1LC
EECS 12		or General Education

ENGRMAE 10
I&C SCI 31[2]

[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 31

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.

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 minor in Earth and Atmospheric Sciences page (http://catalogue.uci.edu/schoolofphysicalsciences/departmentofearthsystemscience/earthandatmosphericsciences_minor/) 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 minor in Global Sustainability page (http://catalogue.uci.edu/interdisciplinarystudies/globalsustainability_minor/) for more information.

Academic Advising

Academic advising is available from academic counselors and peer advisors in the School's Student Affairs Office, 305 Rockwell Engineering Center. *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. However, students are not eligible to declare a second major until they have successfully completed two years with a minimum 3.0 GPA in engineering-related courses.

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. For more complete information, see the Academic Regulations and Procedures section (http://catalogue.uci.edu/informationforadmittedstudents/academicregulationsandprocedures/#gradestext) of this *Catalogue*.

Career Advising

The UCI Division of Career Pathways 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 Division of Career Pathways website (https://career.uci.edu/) for additional information. In addition, special career planning events are held throughout the year including four annual Career Fairs.

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. Latin honor is awarded to the top 16 percent of each quarter's graduates. A list will be generated each fall indicating what the GPA cut-offs are for each category. Students with instances of Academic Dishonesty will be excluded from consideration for this designation.

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
Marvin Maldonado, Interim Director

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 Collegium

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

Graduate Study

Athina Markopoulou, Associate Dean for Graduate and Professional Studies
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Admissions

For information on requirements for admission to graduate study at UCI, contact the appropriate Engineering department, or Graduate and Professional Studies in The Henry Samueli School of Engineering. Additional information is available in the *Catalogue's* Graduate Division (http://catalogue.uci.edu/graduatedivision/#applicationprocedurestext) 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 for some applicants.

Financial Support

Financial assistance is available to Ph.D. students in the form of fellowships, teaching assistantships, and research assistantships. Students should contact the Department to learn more about fellowships and teaching assistantships. 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.

Part-Time Study

Domestic students 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 and Professional Studies and the approval of the Graduate Advisor in their program. 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.

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 solving, design, engineering inventiveness, entrepreneurship, information access, communication, ethics, teamwork, 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 3. Engineering Innovations in Treating Diabetes. 4 Units.
Innovations in diabetes treatment from the 1800s until the present: purification of insulin, measuring and control of blood glucose, recombinant DNA, clinical trials, and ethics. Solving optimization problems in engineering with Excel.

(II and VA).

BME 50A. Cell and Molecular Engineering. 4 Units.
Molecular, structural, genetic, biophysical, and cellular principles of life and bioengineering. Introduction to molecular bioengineering, genetic engineering, synthetic biology, and cell biology. Applications to genetic and biomolecular design.

(Design units: 1)

Prerequisite: CHEM 1C or CHEM H2C

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

BME 50B. Cell and Molecular Engineering. 4 Units.
Physiological function from a cellular, molecular, and biophysical perspective. Introduction to genetics, structure and function of cells and tissues, cell cycle control, cancer, and immunology.

(Design units: 1)

Prerequisite: BME 50A

Restriction: Biomedical Engineering Majors have first consideration for enrollment. Chemical Engineering 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)

Prerequisite: PHYS 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; signal and image processing. Materials fee.

(Design units: 1)

Prerequisite or corequisite: MATH 3A

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; manufacturing planning. Materials fee.

(Design units: 2)

Prerequisite or corequisite: BME 1

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

BME 60D. Engineering Analysis/Design: Finite-Element Simulation. 4 Units.
Introduction to finite-element simulation; fundamentals of Multiphysics simulation;.

(Design units: 2)

Prerequisite: BME 60B and BME 60C

BME 110A. Biomechanics I. 4 Units.
Introduction to statics and dynamics. Topics include rigid bodies, analysis of structures, forces in beams, moments of inertia, friction, kinetics, work, and energy.

(Design units: 1)

Corequisite: BME 60B
Prerequisite: PHYS 7C and MATH 3A and MATH 3D and BME 60B

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

BME 110B. Biomechanics II. 4 Units.
Introduction to biomechanics from subcellular to tissue levels. Introduction to stress, strain, and constitutive laws of cells and tissues. Emphasis is placed on biosolids. Introduction to elastic and viscoelastic behaviors with emphasis on the standard linear model of viscoelasticity.

(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 and Engr Majors have first consideration for enrollment.

BME 110C. Biomechanics III. 4 Units.
Introduction to human biomechanics with emphasis on cardiovascular biomechanics and biofluid mechanics.

(Design units: 0)

Prerequisite: BME 110B

Restriction: Biomedical Engineering Majors have first consideration for enrollment.

BME 111. Design of Biomaterials. 4 Units.
Natural and synthetic polymeric materials. Metal and ceramics implant materials. Mechanical properties, degradation, surface characterization, and design of materials. Wound repair, blood clotting, foreign body response, biocompatibility of material. Artificial organs and medical devices. Government regulations.

(Design units: 3)

Corequisite: BME 50B or BIO SCI 99
Prerequisite: (BME 50B or BIOL 99) and CHEM 1C

Restriction: Biomedical Engineering Majors have first consideration for enrollment. Biomedical Engr: Premedical Majors have first consideration for enrollment. Materials Science and Engr 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 or CHEM H2C) 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 CEE 20 or MAE 10) and MATH 3D and PHYS 7D

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

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 CEE 20 or MAE 10) and MATH 3D and BME 150 and BME 110A

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: BME 60B and (MATH 3A or ICS 6N) and MATH 3D. Recommended: STAT 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.
The use of theories and methods based on computer science, mathematics, and physics in molecular biology and biochemistry. Basics in biomolecular modeling. Analysis of sequence and structural data of biomolecules. Analysis of biomolecular functions.

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

Same as BIOL M123, CS 183.

Concurrent with MBB 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: PHYS 3C or PHYS 7D

Same as BIOL 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: PHYS 7E or PHYS 3C

Restriction: Biomedical Engineering Majors have first consideration for enrollment. Biomedical Engr: Premedical 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 or ICS 6N) and MATH 3D. Recommended: STAT 8.

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

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 signals and data acquisition, bioelectrical signals, design and construction of ECG instrument, bioelectrical signal measurement and analysis. Materials fee.

(Design units: 3)

Prerequisite: BME 60A and BME 130

Restriction: Biomedical Engineering Majors have first consideration for enrollment.

BME 142. Microfabrication. 4 Units.
Essentials of photolithography, soft-lithography, microfabrication, Microelectromechanical Systems (MEMS), BioMEMS; applications in biomedical engineering.

(Design units: 2)

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.

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.

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: 0)

Corequisite: BME 60B or ENGRCEE 20.
Prerequisite: (BME 60B or CEE 20) and MATH 3D and CHEM 1C and PHYS 7E and MATH 2D

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 BIOL 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. Chemical Engineering Majors have first consideration for enrollment.

BME 161. Introduction to Modern Bioengineering Tools. 4 Units.
A broad picture of diverse modern bioengineering tools, including genetic engineering and its risks to society, how to sequence DNA/RNA molecules with single base resolution, how to manipulate small biomolecules one at a time.

Prerequisite: (BME 50A and BME 50B) or (BIOL 97 and BIOL 98 and BIOL 99)

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. Materials fee.

(Design units: 1)

Prerequisite: BME 50B and BME 120 and BME 130

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 179. Biomedical Engineering Design: Addressing Unmet Clinical Needs. 3 Units.
Introduction to unmet clinical needs identification and evaluation in biomedical engineering design.

Prerequisite: (BME 60B or MAE 10 or EECS 10) and (BME 60C or MAE 52 or EECS 31L)

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; industrial design experience in group projects; ethics, economic analysis, and FDA product approval. Materials fee.

(Design units: 3)

Prerequisite: (BME 60B or MAE 10 or EECS 10) and (BME 60C or MAE 52 or EECS 31L) and (BME 140 or MAE 106 or EECS 170B). 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; industrial design experience in group projects; 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; industrial design experience in group projects; ethics, economic analysis, 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 198. Biomedical Engineering Internship. 2-12 Units.
Students majoring in BME may receive credit for an approved internship, working at a company under the supervision of an industry mentor and a faculty advisor. Enables students to gain valuable experience in a professional setting and enhance their skills.

Grading Option: Pass/no pass only.

Repeatability: May be taken for credit 3 times.

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)

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 201P. Biomedical Big Data. 4 Units.
Analysis and visualization of large biomedical datasets. Topics covered include cloud computing, learning Structured Query Language (SQL), database normalization and joins, using Google's BigQuery, using the statistical analysis package R, machine learning algorithms, application of machine learning for classification problems.

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

BME 202P. Biomedical Imaging and Biophotonics. 4 Units.
Designed as a subfield of optical imaging and biophotonics as it applies to their applications to basic lifesciences and in vivo imaging to diagnose disease. Topics span all of of the areas of biophotonics and techniques.

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

BME 203P. Digital Health. 4 Units.
Digital health is the convergence of genomics and technology to radically change the way health and medicine is practiced. Explores the history of healthcare in the U.S., its current status, and the future of digital health.

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

BME 204P. Personalized Medical Devices. 4 Units.
Introduces students to fundamental aspects of medical devices and discusses therapeutic as well as diagnostic devices. Basic aspects of microfluidics and biology critical to personalized medical systems are studied. Typical FDA approval pathways for medical devices are presented.

Restriction: Master of Engineering students only.

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 210P. 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: Master of Engineering students only. 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 211P. 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: Master of Engineering students only. 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 212P. 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: Master of Engineering students only. 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 DEVB 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. BME 220 with a grade of B- or better. BME 221 with a grade of B- or better

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.

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

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

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 221P. Organ Transport Systems. 4 Units.
Applies engineering models and mathematics to understand human physiology in order to understand the physiology. Covers the pulmonary, cardiac, and cardiovascular systems focusing on transport phenomena.

Restriction: Master of Engineering students only. 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 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 230P. Introduction to Machine Learning. 4 Units.
Introduces fundamental concepts in programming and machine learning. The goal is to provide an accessible introduction to the field of machine learning and related techniques for students with a wide variety of engineering degrees.

Same as ENGR 230P, CEE 230P, EECS 230P, MAE 230P.

Restriction: Master of Engineering students only.

BME 232. Introduction to Computational Biology. 4 Units.
The use of theories and methods based on computer science, mathematics, and physics in molecular biology and biochemistry. Basics in biomolecular modeling. Analysis of sequence and structural data of biomolecules. Analysis of biomolecular functions.

Same as MBB 223.

Restriction: Graduate students only.

Concurrent with BIOL M123 and CS 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 233P. Dynamic Systems in Biology and Medicine. 4 Units.
Introduces the elements of system theory, and applies these principles to analyze biomedical, chemical, social, and engineering systems. Using analytical and computational tools to model and analyze various dynamic systems.

Restriction: Master of Engineering students only. 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 234P. 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: Master of Engineering students only. Graduate students only.

BME 235. Analysis of Neural Time Series. 4 Units.
Hands-on introduction to techniques for the analysis of neural time series data, with a primary focus on the electroencephalogram (EEG). Topics may include the physiological basis of EEG, time-frequency analysis, spatial filtering, and methods of assessing connectivity.

Same as COGS 235.

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 238P. 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: Master of Engineering students only. Graduate students only.

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 240P. 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: Master of Engineering students only. 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.

Concurrent with BME 136.

BME 251P. 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: Master of Engineering students only. Graduate students only.

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

Prerequisite: BME 224 or BME 225. BME 224 with a grade of B- or better. BME 225 with a grade of B- or better

Repeatability: May be taken for credit 2 times.

Restriction: Graduate students only.

BME 255. Cardiovascular Devices. 4 Units.
Cardiovascular implants, the science around those, regulatory affairs, and cardiovascular device market and related business opportunities. Students form practice startups around a clinical unmet need and use their knowledge from the course to plan it accordingly.

Restriction: Graduate students only.

BME 260P. 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, biolmolecular manipulation, separation and detection, and the technologies for integrating these devices into microsystems.

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

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.

BME 262P. 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: Master of Engineering students only. 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. Biomedical Engineering Majors 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 295P. Special Topics in Biomedical Engineering. 4 Units.
Studies in selected areas of Biomedical Engineering. Topics addressed vary each quarter.

Prerequisite: Prerequisites vary.

Repeatability: Unlimited as topics vary.

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

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: Unlimited as topics vary.

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.

Chemical and Biomolecular Engr Courses

CBE 1. Introduction to Chemical Engineering. 1 Unit.
Helps new students successfully transition to UCI, build a sense of community in the department, develop networking and professional skills, and introduce a variety of industries who employ chemical engineers through a series of guest lectures.

Grading Option: Pass/no pass only.

Restriction: Chemical Engineering Majors have first consideration for enrollment.

CBE 40A. Chemical Processes and Material 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.

Prerequisite: MATH 2B and PHYS 7C and (CHEM 1B or CHEM H2B)

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

CBE 40B. Process Thermodynamics. 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.

Prerequisite: CBE 40A and (MATH 3A or ICS 6N). CBE 40A with a grade of C- or better

Restriction: Chemical Engineering Majors have first consideration for enrollment.

CBE 40C. 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.

Corequisite: ENGRMAE 10
Prerequisite: MAE 10 and MATH 2D and CBE 40B. CBE 40B with a grade of C- or better

Restriction: Chemical Engineering Majors have first consideration for enrollment.

CBE 100. 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.

Prerequisite: CBE 40C

Restriction: Chemical Engineering Majors have first consideration for enrollment.

CBE 105. Engineering Physical Chemistry. 4 Units.
Provides an integrated view of both classical and molecular perspectives on thermodynamics, thermodynamic potentials, entropy, and the second law. Students learn how to use statistical mechanics to create a bridge between the quantum mechanical world and the familiar macroscopic one.

Prerequisite: CHEM 1C and CBE 40C and (PHYS 7D or PHYS 7E)

Overlaps with CHEM 132A, CHEM 132B, CHEM 132C.

Restriction: Chemical Engineering Majors have first consideration for enrollment.

CBE 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.

Prerequisite: CHEM 1C and MATH 3D and CBE 40B and CBE 40C and CBE 100. CBE 40B with a grade of C- or better. CBE 40C with a grade of C- or better

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

CBE 120A. 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.

Prerequisite: CBE 40C and MATH 3D. CBE 40C with a grade of C- or better

Restriction: Chemical Engineering Majors have first consideration for enrollment.

CBE 120B. 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.

Prerequisite: CBE 120A. CBE 120A with a grade of C- or better

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

CBE 120C. 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.

Prerequisite: CBE 120B and CBE 100

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

CBE 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.

Prerequisite: CBE 40B and CBE 40C. CBE 40B with a grade of C- or better. CBE 40C with a grade of C- or better

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

CBE 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.

Prerequisite: CBE 110 and CBE 120C

Restriction: Chemical Engineering Majors have first consideration for enrollment.

CBE 140B. Chemical Engineering Laboratory II. 4 Units.
Continuation of the CBE 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.

Prerequisite: CBE 130 and CBE 145 and CBE 140A

Restriction: Chemical Engineering Majors have first consideration for enrollment.

CBE 145. 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.

Prerequisite: CBE 110 and CBE 120B and CBE 120C

Restriction: Chemical Engineering Majors have first consideration for enrollment.

CBE 150A. 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.

Prerequisite: CBE 110 and CBE 120C and CBE 130

Restriction: Seniors only. Chemical Engineering Majors only.

CBE 150B. 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.

Prerequisite: CBE 150A

Restriction: Seniors only. Chemical Engineering Majors only.

CBE 160. Engineering Biology. 3 Units.
First-principle introduction to the modern biochemistry, molecular biology, and cell biology with an engineering language. The goal is to demonstrate that the vastly diverse biological phenomena can be explained by a set of fundamental principles in chemistry, thermodynamics, and kinetics.

CBE 161. 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.

Prerequisite: CBE 110 and CBE 160 and (CHEM 1C or CHEM H2C) and MATH 3D

Restriction: Chemical Engineering Majors have first consideration for enrollment.

CBE 163. 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.

Prerequisite: CBE 120A and CBE 160

Restriction: Chemical Engineering Majors have first consideration for enrollment.

CBE 172. Applied Spectroscopy. 4 Units.
Designed to teach fundamental principles of spectroscopy and their application to photon and electron spectroscopies of the gas and condensed phases. Covers theoretical principles of rotational, vibrational, and electronic spectroscopies. Specific topics include infrared and Raman spectroscopies, Auger, X-ray, etc.

Prerequisite: CBE 40C and CBE 105 and MATH 3D

Concurrent with CBE 272.

CBE 175. Electrochemical Engineering. 4 Units.
Introduction to fundamentals of electrochemical engineering and its application to variety of energy conversion- and storage-technologies. Planned topics include: electric double layers, reaction kinetics, transport, batteries, fuel-cells.

CBE 176. 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.

Prerequisite: (CHEM M3C or CHEM 1C or CHEM H2C or CHEM M2C) and MATH 2D

Same as CHEM 133.

Restriction: Chemistry Majors have first consideration for enrollment. Chemical Engineering Majors have first consideration for enrollment.

Concurrent with CHEM 233 and CBE 276.

CBE 181. 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.

Prerequisite: ENGR 54 and (CBE 110 or MSE 165)

Restriction: Chemical Engineering Majors have first consideration for enrollment.

CBE 183. 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: (CBE 110 or MSE 165C) and (MSE 141 or MSE 69)

Same as MSE 176.

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

Concurrent with MSE 276 and CBE 283.

CBE 187. 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 are covered.

Prerequisite: CBE 40B

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

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

Prerequisite: Prerequisites vary.

Repeatability: Unlimited as topics vary.

CBE 197. Chemical and Biomolecular Engineering Internship. 2-12 Units.
Students majoring in CBE may receive credit for an approved internship, working at a company under the supervision of an industry mentor and a faculty advisor. Enables students to gain valuable experience in a professional setting and enhance their skills.

Grading Option: Pass/no pass only.

Repeatability: May be taken for credit 3 times.

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

Repeatability: May be repeated for credit unlimited times.

Restriction: Upper-division students only.

CBE 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.

Repeatability: May be taken for credit for 8 units.

Restriction: Chemical Engineering Majors have first consideration for enrollment.

CBE 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.

Grading Option: Pass/no pass only.

Repeatability: May be repeated for credit unlimited times.

CBE 200. Applied Engineering Mathematics I. 4 Units.
Analytical techniques applied to engineering problems in transport phenomena, process dynamics and control, and thermodynamics.

Restriction: Graduate students only.

CBE 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.

CBE 220A. Transport Phenomena I. 4 Units.
Continuum modeling and analysis of heat and mass transfer from an integrated viewpoint. Scaling concepts, relevance of characteristic time- and length-scales, steady- and unsteady-state processes, bounded and unbounded problems, and convective transport, with applications to chemical and biological processes.

Restriction: Graduate students only.

CBE 220B. Transport Phenomena II. 4 Units.
Introduces flow of isothermal fluids from a momentum transport viewpoint. Steady- and unsteady-state creeping and laminar flows; viscous and inviscid flows; Navier-Stokes equations; lubrication theory; boundary layer theory; with specific application to complex chemical and biological engineering processes.

Prerequisite: CBE 220A. CBE 220A with a grade of B- or better

Restriction: Graduate students only.

CBE 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; microscope rigorous equations of state; molecular-level thermodynamics of real mixtures; and phase and chemical equilibrium.

Restriction: Graduate students only.

CBE 249. Special Topics in Chemical Engineering. 1-4 Units.
Studies in selected areas of Chemical Engineering. Topics addressed vary each quarter.

Prerequisite: Prerequisites vary.

Repeatability: Unlimited as topics vary.

Restriction: Graduate students only.

CBE 250. Research Methods and Technical Communication. 4 Units.
Intended for Ph.D. students to develop critical research skills in creating archival papers, intellectual property and technical proposals, and in analysis of the scientific literature.

Restriction: Graduate students only.

CBE 261. Molecular Biotechnology. 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.

CBE 262. Metabolic Engineering and Synthetic Biology. 4 Units.
Synthesis of chemicals from renewable carbon and energy sources using.

Restriction: Graduate students only.

CBE 264. 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.

CBE 266. Bioseparation Processes. 4 Units.
Introduction to design of bioseparation processes. The recovery and purification of biologically produced proteins, chemicals, and particulates are important. Focuses on the use of chemical engineering skills and principles in the analysis and design of biologically-based processes.

Restriction: Graduate students only.

CBE 271. Catalysis. 4 Units.
Establish the microscopic thermodynamics of rate constants and develop quantitative rate laws to model multistep reaction kinetics typical of catalyzed reactions. Common elementary chemical transformations and characteristics of catalytic materials are discussed, citing reactions from industry and current research.

Restriction: Graduate students only.

Concurrent with CBE 171.

CBE 272. Applied Spectroscopy. 4 Units.
Designed to teach fundamental principles of spectroscopy and their application to photon and electron spectroscopies of the gas and condensed phases. Covers theoretical principles of rotational, vibrational, and electronic spectroscopies. Specific topics include infrared and Raman spectroscopies, Auger, X-ray, etc.

Restriction: Graduate students only.

Concurrent with CBE 172.

CBE 276. 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.

Concurrent with CHEM 133 and CBE 176.

CBE 277. 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 CBE 276. CHEM 233 with a grade of B- or better. CBE 276 with a grade of B- or better

Same as CHEM 244.

Restriction: Graduate students only.

CBE 280. Advanced Polymer Science and Engineering. 4 Units.
The synthesis, characterization, microstructure, rheology, and properties of polymer materials. Polymers in solution and in the liquid, crystalline and glassy states. Engineering and processing properties, including viscoelasticity and rheology. Forming and processing methods. Environmental issues.

Restriction: Graduate students only.

CBE 282. 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.

CBE 283. 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.

Same as MSE 276.

Restriction: Graduate students only.

Concurrent with MSE 176 and CBE 183.

CBE 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.

CBE 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.

CBE 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.

CBE 298. Seminars in Engineering. 2 Units.
Presentation of advanced topics and reports of current research efforts in chemical engineering.

Grading Option: Satisfactory/unsatisfactory only.

Repeatability: May be repeated for credit unlimited times.

Restriction: Graduate students only.

CBE 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.

(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.

(Design units: 1)

Corequisite: MATH 3D
Prerequisite: (ENGRCEE 20 or BME 60B) and (MATH 3A or I&C SCI 6N)

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 40. Fundamentals of Economic Analysis for Scientists and Engineers. 4 Units.
Introduction to microeconomics and cost benefit analysis. Integration of economic, social, and behavioral considerations into the engineering design process. Applications to contemporary problems via case studies.

(III)

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.

(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 and Engr 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. 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 or I&C SCI 6N) and MATH 3D

Restriction: Civil Engineering Majors have first consideration for enrollment.

ENGRCEE 114. GIS for Civil and Environmental Engineering. 4 Units.
GIS for CEE provides an introduction to Geographic Information Systems (GIS) and their various applications in civil and environmental engineering. Topics include GIS data formats, data queries, spatial and attribute data, spatial data analysis, coordinate systems, and raster data analysis.

Concurrent with ENGRCEE 214.

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 and 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.

Concurrent with ENGRCEE 229A.

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 125. Transportation and the Environment. 4 Units.
Analysis of the impacts of motor vehicle transportation on the environment. Introduction to life cycle analysis applied to transportation. Basic economic tools for transportation externalities. Transportation planning, urban form, health, and the environment. Transportation sustainability.

(Design units: 0)

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.
Nature of earthquakes, hazard analyses, structural dynamics for earthquake engineering, seismic design force determination methods: ELF, modal response spectrum, nonlinear time history analyses. Diaphragm analyses, redundancy, nonlinear response, ductile systems, hysteretic behavior. Basics of seismic design for steel, timber, concrete.

(Design units: 2)

Prerequisite: ENGRCEE 11 and (ENGRCEE 20 or BME 60B) and ENGRCEE 151A

Restriction: Civil Engineering Majors have first consideration for enrollment.

Concurrent with ENGRCEE 249.

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 or ENGRMAE 30 or ENGR 30. ENGRCEE 30 with a grade of C- or better. ENGRMAE 30 with a grade of C- or better. ENGR 30 with a grade of C- or better

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 or ENGRMAE 30 or ENGR 30) and ENGRCEE 150. ENGRCEE 30 with a grade of C- or better. ENGRMAE 30 with a grade of C- or better. ENGR 30 with a grade of C- or better

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.
Fundamentals of structural analysis and loading. Deformation of statically determinate and indeterminate structures. Influence lines. Structural systems.

(Design units: 0)

Prerequisite: ENGRCEE 150 or ENGRMAE 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.
Ultimate strength design. Design of reinforced concrete beam sections. Design for shear and deflection. Design of columns. Design of isolated and combined footings. Laboratory sessions. Materials fee.

(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.
Introduction to environmental processes in air and water, mass balances, and transport phenomena. Fundamentals of water-quality engineering including water and wastewater treatment.

(Design units: 1)

Prerequisite: (CHEM 1B or CHEM H2B) and ENGRCEE 170

Restriction: Civil Engineering Majors have first consideration for enrollment. Chemical 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 or CHEM H2A) and (CHEM 1B or CHEM H2B) and (CHEM 1LC or CHEM 1LE or CHEM H2LB or CHEM M2LB) and (CHEM 51A or CHEM H52A)

Restriction: Chemical Engineering Majors have first consideration for enrollment. Environmental 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. Chemical 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 163 or ENGRCEE 165

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 CBE 40C)

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

Concurrent with ENGRCEE 265.

ENGRCEE 166. Microbial Processes for Bioremediation. 4 Units.
Fundamental knowledge on microbiology, organic chemistry, biodegradability and persistence, reaction kinetics, and contaminant transport of water and soil remediation of organic contaminants under aerobic and anaerobic conditions. Overview of Environmental Law and Superfund. Design project of bioremediation for contaminated site.

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

Concurrent with ENGRCEE 206P.

ENGRCEE 168. Microorganisms and Climate Change. 4 Units.
Climate change and impacts on microbial processes: greenhouse gas generation, biogeochemical cycles, permafrost thawing, ocean acidification, eutrophication, pathogen proliferation. Microorganism-based solutions that can mitigate climate change impacts (microbial greenhouse control, production of lower carbon and energy footprint goods, carbon sequestration).

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

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 or ENGRMAE 130A or CBE 120A

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

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 BME 60B or ENGRMAE 10) and (ENGRCEE 170 or ENGRMAE 130A or CBE 120A)

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

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: Seniors only. 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 (Letter Grade with P/NP).

Restriction: Seniors only. 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: Seniors only. 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 197. Civil and Environmental Engineering Internship. 2-12 Units.
Students majoring in CEE may receive credit for an approved internship, working at a company under the supervision of an industry mentor and a faculty advisor. Enables students to gain valuable experience in a professional setting and enhance their skills.

Grading Option: Pass/no pass only.

Repeatability: May be taken for credit 3 times.

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 201P. Life Cycle Assessment Methods. 4 Units.
Introduction and application of life cycle assessment methods for.

Restriction: Master of Engineering students only.

ENGRCEE 202P. Green Building Design. 4 Units.
Application of life cycle assessment methods to green and sustainable.

Restriction: Master of Engineering students only.

ENGRCEE 204P. Fundamentals of Sustainable Engineering. 4 Units.
Introduction to sustainability and its connection to environmental engineering infrastructure: economic/social sustainability, lifecycle assessment/cost, water and waste management, empathy in engineering, quantitative approaches for social sustainability, and decision-making across sustainability metrics. Includes guest lectures and field trips.

Restriction: Master of Engineering students only.

ENGRCEE 205P. Wastewater Treatment Process Design. 4 Units.
Process design for wastewater treatment. Topics include solids separation, biological treatment, aeration, sludge stabilization, process control, and economics. Design projects included.

Restriction: Master of Engineering students only.

Concurrent with ENGRCEE 163.

ENGRCEE 206P. Biological Processes for Bioremediation. 4 Units.
Fundamental knowledge on microbiology, organic chemistry, biodegradability and persistence, reaction kinetics, and for development of water and soil.

Restriction: Master of Engineering students only.

Concurrent with ENGRCEE 166.

ENGRCEE 210P. Smart City Transport Systems. 4 Units.
Focuses on engineering methods and concepts associated with smart cities and applies these methods and concepts to analyze emerging and future.

Restriction: Master of Engineering students only.

ENGRCEE 211P. Sustainable Transportation. 4 Units.
Overview of the impacts of transportation on the environment, with an.

Restriction: Master of Engineering students only.

ENGRCEE 212P. Transportation Policy and Technology. 4 Units.
The process of planning, designing, and managing the transportation.

Restriction: Master of Engineering students only.

ENGRCEE 214. GIS for Civil and Environmental Engineering. 4 Units.
GIS for CEE provides an introduction to Geographic Information Systems (GIS) and their various applications in civil and environmental engineering. Topics include GIS data formats, data queries, spatial and attribute data, spatial data analysis, coordinate systems, raster data analysis.

Concurrent with ENGRCEE 114.

ENGRCEE 220A. Travel Demand Analysis I. 4 Units.
Fundamentals of transportation systems analysis. Theoretical aspects of travel demand. Travel behavior. Modeling of performance characteristics and costs of transportation modes. In-depth presentation of travel demand modeling techniques. Development of travel choice models including mode, route, and destination choice. Equilibrium.

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. ENGRCEE 220A with a grade of B- or better

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 separtate these two approaches and presenting appropriate mathematical and statistical tools to address these distinctions.

Prerequisite: ENGRCEE 220A. ENGRCEE 220A with a grade of B- or better

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. ENGRCEE 221A with a grade of B- or better

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 226A. Traffic Flow Theory I. 4 Units.
Traffic measurement and fundamental speed-density-flow relationships. Kinematic models. Shock waves. Statistical-kinetic theory of traffic. Introductory car-following principles and stability. Gap acceptance. Platoon dispersion. Two-fluid model. Queueing process. Multi-regime and catastrophe models. Higher-order continuum models. Microscopic and macroscopic simulation.

Restriction: Graduate students only.

ENGRCEE 226B. Traffic Flow Theory II. 4 Units.
Advanced mathematical analysis of vehicular flow. Detailed treatise on car-following models. Fourier and Laplace analysis of stability problems. Perturbation analysis. Derivation of macroscopic traffic flow relationships from microscopic considerations. Advanced hydrodynamic theory.

Prerequisite: ENGRCEE 226A. ENGRCEE 226A with a grade of B- or better

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. ENGRCEE 220A with a grade of B- or better

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. ENGRCEE 221A with a grade of B- or better. ENGRCEE 228A with a grade of B- or better

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.

Concurrent with ENGRCEE 122.

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. ENGRCEE 229A with a grade of B- or better

Restriction: Graduate students only.

ENGRCEE 230P. Introduction to Machine Learning. 4 Units.
Introduces fundamental concepts in programming and machine learning. The goal is to provide an accessible introduction to the field of machine learning and related techniques for students with a wide variety of engineering degrees.

Same as BME 230P, ENGR 230P, EECS 230P, ENGRMAE 230P.

Restriction: Master of Engineering 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 231P. 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: Master of Engineering 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 240. High Performance Materials. 4 Units.
Part I: Linear and nonlinear fracture mechanics, methodology, real-world case studies; Part II: Composite material toughening, underlying micromechanics, materials engineering towards microstructure tailoring and new material design approaches; Part III: Emerging high-performance engineering materials for safety, energy and the environment.

Restriction: Graduate students only.

ENGRCEE 242. Advanced Strength of Materials. 4 Units.
Beams on elastic foundations. Combined axial and lateral loads. Curved beams. Unsymmetric bending. Shear center. Stresses and strains. Basic equations for theory of elasticity. Energy principles. Theory of torsion. Combined bending and torsion.

Restriction: Graduate students only.

ENGRCEE 247. Structural Dynamics. 4 Units.
Vibration of discrete and continuous mass elastic systems. Isolation and transmissability. Dynamic recording instruments. Introduction to nonlinear theory of vibration. Response of structures to earthquake, traffic, and wind loads. Response spectra concepts. Normal mode analysis. Numerical integration techniques.

Restriction: Graduate students only.

ENGRCEE 247P. Structural Dynamics. 4 Units.
Dynamic equilibrium of structures. Response of a single degree of.

Restriction: Master of Engineering students only.

ENGRCEE 249. Earthquake Engineering. 4 Units.
Nature of earthquakes, hazard analyses, structural dynamics for earthquake engineering, seismic design force determination methods: ELF, modal response spectrum, nonlinear time history analyses. Diaphragm analyses, redundancy, nonlinear response, ductile systems, hysteretic behavior. Basics of seismic design for steel, timber, concrete.

Restriction: Graduate students only.

Concurrent with ENGRCEE 149.

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 250P. Finite Element Method in Structural Engineering. 4 Units.
Finite element concepts in structural engineering including.

Restriction: Master of Engineering students only.

ENGRCEE 251. Performance-Based Structural Engineering. 4 Units.
Introduction and implementation of current approaches in performance-based assessment and design of building structures. Emphasis is on applied and evolving methods and tools for exercising performance-based engineering of building structures.

Prerequisite: ENGRCEE 247 and ENGRCEE 249. ENGRCEE 247 with a grade of B- or better. ENGRCEE 249 with a grade of B- or better

Restriction: Graduate students only.

ENGRCEE 252. Multiscale Modeling of Materials and Structures. 4 Units.
Introduction to modeling materials and structures across length.

Restriction: Graduate students only.

ENGRCEE 253. Micromechanics. 4 Units.
Micromechanics concepts in solid mechanics including eigenstrains, Eshelby equivalent inclusion theories, homogenization procedures, Mori-Tanaka method, self-consistent scheme, and effective mechanical behavior of composites.

Restriction: Graduate students only.

ENGRCEE 254. Advanced Reinforced Concrete Behavior and Design. 4 Units.
Flexural strength of reinforced concrete elements. Flexural ductility of unconfined and confined members with axial loads. Shear and torsional behaviors. Strength of reinforced concrete ductile frames and shear walls. Reinforced concrete detailing.

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.
Objectives of seismic design. Cyclic load-distortion characteristics of typical structural elements. Desirable structural form. Ductility and methods of achieving it. Use of energy dissipators. Project involving design of multistory, multibay rigid-jointed plane frame.

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 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 264P. 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.

Prerequisite: Undergraduate-level introduction to environmental processes, mass balances, and transport phenomena.

Restriction: Master of Engineering students only.

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 266P. Biological Process Design. 4 Units.
Applied microbiology and engineering principles to understand and solve.

Restriction: Master of Engineering students only.

ENGRCEE 268. Environmental Fluid Mechanics and Turbulence. 4 Units.
Covers the nonlinear physics of turbulence flows with a focus on environmental applications.

Restriction: Graduate students only.

ENGRCEE 269. Beach Dynamics. 4 Units.
Coastal erosion in California, human and natural influences on southern California beaches, and present-day challenges. Littoral cells and sediment budgets. Water wave theory. Littoral sediment transport and shoreline change modeling. Shoreline stabilization using green and gray infrastructure.

Restriction: Graduate students only.

ENGRCEE 269P. Beach Dynamics. 4 Units.
Provides an introduction to the processes that influence coastal.

Restriction: Master of Engineering students only.

ENGRCEE 270. Flood Risk and Modeling. 4 Units.
Global and national trends in flooding and related impacts including disasters; flood risk management; theory and numerical methods for flood inundation modeling; flood risk communication strategies including flood hazard visualizations.

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. Stochastic Hydrology. 4 Units.
Statistical analysis and modeling of hydrologic and geophysical data for decision making, frequency analysis of extreme precipitation and floods for hydrologic design, time series analysis for hydrological simulation, spectral analysis, and geostatistical analysis of spatially correlated fields.

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.

Restriction: Graduate students only.

ENGRCEE 279. Environmental Transport 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.

Restriction: Graduate students only.

ENGRCEE 281. Structural Reliability. 4 Units.
Applications of probability theory to reliability analysis of engineering structures. Theory of structural reliability. Estimation of static random loads. Reliability analysis of structural components and system. Monte Carlo simulation.

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 289. Analysis of Hydrologic Systems. 4 Units.
Application of systems theory in hydrologic, land surface, biogeochemical modeling. Design, identification, and calibration of conceptual models. Principles of dynamic systems, modeling approaches, theory of linear systems, mathematical concepts of differential calculus, theoretical concepts of parameter estimation and optimization theory.

ENGRCEE 290A. Machine, Model, and Statistical Learning I. 4 Units.
Introduction to machine, model, and statistical learning, featuring a.

Prerequisite: Recommended: Foundational skills in Mathematics, Statistics, and MATLAB.

Restriction: Graduate students only.

ENGRCEE 290B. Machine, Model, and Statistical Learning II. 4 Units.
Advanced mathematical concepts in machine, model, and statistical learning. Linear algebra, information, probability, and set theory. Topics include sensitivity analysis, forecast verification, model selection, model averaging, data assimilation (Kalman filter), and sequential Monte Carlo (particle filter).

Prerequisite: ENGRCEE 290A. ENGRCEE 290A with a grade of B- or better

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. ENGRCEE 276 with a grade of B- or better

Restriction: Graduate students only.

ENGRCEE 292. Wavelets in Hydrology, Engineering, and Geoscience. 4 Units.
Multiscale analysis of hydrologic, engineering, and earth system processes; energy decomposition in the time-frequency domain via wavelets; applications to fluid flows, climate and mechanical signals for feature extraction, trend analysis, coherent structures, and upscaling/downscaling.

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 295P. Special Topics in Civil and Environmental Engineering. 4 Units.
Studies in selected areas of Civil and Environmental Engineering. Topics addressed vary each quarter.

Repeatability: May be taken for credit 1 times as topics vary.

Restriction: Master of Engineering 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 and Environmental Engineering. 1-4 Units.
Presentation of advanced topics and special research areas in civil and environmental 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: PHYS 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.

(Design units: 0)

Restriction: Electrical Engineering Majors have first consideration for enrollment.

EECS 10. Computational Methods in Electrical and Computer Engineering. 4 Units.
An introduction to computers and structured programming. Binary Data Representation. Hands-on experience with a high-level structured programming language. Introduction to algorithm efficiency. Applications of structured programming in solving engineering problems. Programming laboratory.

(Design units: 0)

Prerequisite or corequisite: MATH 2A

Overlaps with EECS 12.

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

EECS 12. Introduction to Programming. 4 Units.
An introduction to computers and programming. Python programming syntax/style, types. Numbers and sequences. Control flow. I/O and errors/exceptions. Function calling, parameter passing, formal arguments, return values. Variable scoping. Programming laboratory.

(Design units: 0)

Corequisite: MATH 2A

Overlaps with EECS 10.

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.
C language programming concepts. Control flow, function calls, recursion. Basic and composite data types, static and dynamic data structures. Program modules and compilation units. Preprocessor macros. C standard libraries.

(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: ICS 31 or EECS 10 or EECS 12 or MAE 10 or ICS 32A

Restriction: Computer Engineering Majors have first consideration for enrollment. Computer Science Engineering Majors have first consideration for enrollment. Electrical 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 ICS 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.
Primitive types and expressions. The class and method definition. Information hiding and encapsulation. Objects and reference. Overloading. Constructors. Inheritance basics. Programming with inheritance. Dynamic binding and polymorphism. Exception handling. An overview of streams and file input/output. Programming laboratory.

(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.
Modeling and analysis of electrical networks. Basic network theorems. Sinusoidal steady state and transient analysis of RLC networks and the impedance concept.

(Design units: 1)

Corequisite: MATH 3D
Prerequisite: PHYS 7D and (EECS 10 or EECS 12 or MAE 10 or ICS 31 or CEE 20)

Overlaps with MAE 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 and Engr Majors have first consideration for enrollment. Environmental Engineering Majors have first consideration for enrollment.

EECS 70B. Network Analysis II. 4 Units.
Laplace transforms, complex frequency, and the s-plane. Network functions and frequency response, including resonance. Bode plots. Two-port network characterization.

(Design units: 1)

Corequisite: EECS 70LB
Prerequisite: (BME 60B or EECS 10 or EECS 12 or ICS 31 or CEE 20 or MAE 10) and EECS 70A

Restriction: Electrical Engineering Majors have first consideration for enrollment. Computer Engineering Majors have first consideration for enrollment. Materials Science and Engr 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: PHYS 7D and (EECS 10 or EECS 12 or BME 60B or CEE 20 or MAE 10)

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

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 ICS 31 or CEE 20 or MAE 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: 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 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 (ICS 46 or EECS 114)

Overlaps with CS 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/out devices and interfaces. Microprogramming and microprocessors.

(Design units: 4)

Prerequisite: EECS 31L

Overlaps with CS 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. Computer Science and Engineering Majors have second 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. Computer Science Engineering Majors have second 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: ICS 33 or EECS 114. ICS 33 with a grade of C or better

Same as CS 122A.

Restriction: School of Info & Computer Sci students have first consideration for enrollment. Computer Science Engineering Majors have first consideration for enrollment.

EECS 117. Parallel Computer Systems. 3 Units.
General introduction to parallel computing focusing on parallel algorithms and architectures. Parallel models: Flynn's taxonomy, dataflow models. Parallel architectures: systolic arrays, hypercube architecture, shared memory machines, dataflow machines, reconfigurable architectures. Parallel algorithms appropriate to each machine type area also discussed.

(Design units: 1)

Prerequisite: EECS 20 and EECS 114 and EECS 112

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

EECS 118. Introduction to Artificial Intelligence. 4 Units.
Introduction of basic concepts in artificial intelligence. Knowledge representation and reasoning, search, planning, declarative programing, problem solving, and data science.

(Design units: 2)

Prerequisite: EECS 114

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

EECS 120. Fundamentals of Parallel Computing. 4 Units.
Fundamentals of parallel computing, focusing on parallel algorithms and architectures. Topics include 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 12 or CS 152) and EECS 114

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

EECS 121. System Security. 3 Units.
Fundamentals and practices of system security. Topics include cryptographic (encryption, decryption, and message authentication), software vulnerabilities (buffer overflow), network security (layer 2-7 attacks and defenses and PKI), web security (XSS and XSRF), and privacy.

Prerequisite: EECS 22 or ICS 45C

EECS 125. Introduction to Machine Learning for Engineers. 4 Units.
Introduction to ML with a special focus on engineering applications. Starts with a mathematical background required for ML and covers various models for supervised learning (classification and regression) and unsupervised learning (clustering).

Prerequisite: EECS 55 and EECS 145 and EECS 12. Recommended: EECS 114.

Overlaps with CS 178.

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 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 141B. Communication Systems II. 3 Units.
Signal space analysis. Optimum receivers for digital communication. Maximum a posteriori and maximum likelihood detection. Matched filter and correlation receiver. PAM, QAM, PSK, FSK, and MSK and their performance. Introduction to equalization, synchronization, information theory, and error control codes.

(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.
Analysis and synthesis of antennas and antenna arrays. Adaptive arrays and digital beam forming for advanced wireless links. Friis transmission formula. Wireless communication equations for cell-site and mobile antennas, interference, slow and fast fading in mobile communication.

(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: Electrical Engineering Majors have first consideration for enrollment. Computer Engineering Majors have first consideration for enrollment. Computer Science Engineering majors have second 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 STAT 67

Same as CS 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 MATH 3D

Restriction: Computer Engineering Majors have first consideration for enrollment. Electrical Engineering Majors have first consideration for enrollment. Computer Science Engineering Majors have second 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 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 CS 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. Materials fee.

(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 EECS 12 or MAE 10 or BME 60B or CEE 20) and EECS 150 and EECS 170B and EECS 170LB

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

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. Computer Engineering Majors have second consideration for enrollment. Computer Science Engineering Majors have second 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: PHYS 7E
Prerequisite: PHYS 7D and EECS 70B

Restriction: Electrical Engineering Majors have first consideration for enrollment. Computer Engineering Majors have first consideration for enrollment. Computer Science Engineering Majors have second 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: Electrical Engineering Majors have first consideration for enrollment. Computer Engineering Majors have first consideration for enrollment. Materials Science and Engr Majors have first consideration for enrollment. Computer Science Engineering Majors have second 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. Computer Engineering Majors have second consideration for enrollment. Computer Science Engineering Majors have second 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 second consideration for enrollment. Computer Science Engineering Majors have second 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

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

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 PHYS 7E
Prerequisite: PHYS 7D and EECS 70B

Restriction: Electrical Engineering Majors have first consideration for enrollment. Computer Engineering Majors have first consideration for enrollment. Materials Science and Engr 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: Electrical Engineering Majors have first consideration for enrollment. Computer Engineering Majors have first consideration for enrollment. Computer Science Engineering Majors have second 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. Computer Engineering Majors have second consideration for enrollment. Computer Science Engineering Majors have second 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. Computer Science Engineering Majors have second consideration for enrollment. Materials Science Engineering Majors have second 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: Computer Science Engineering Majors have first consideration for enrollment. Electrical Engineering Majors have first consideration for enrollment. Materials Science and Engr 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. Computer Science Engineering Majors have first consideration for enrollment. Electrical 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.

(Design units: 1)

Prerequisite: PHYS 7E and EECS 145

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

(Design units: 1)

Prerequisite: EECS 180A

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

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

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. Computer Science Engineering Majors have second 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 197. Electrical Engineering and Computer Science Internship. 2-12 Units.
Students majoring in EECS may receive credit for an approved internship, working at a company under the supervision of an industry mentor and a faculty advisor. Enables students to gain valuable experience in a professional setting and enhance their skills.

Grading Option: Pass/no pass only.

Repeatability: May be taken for credit 3 times.

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

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

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 203P. 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: Master of Engineering students only. Graduate students only.

EECS 204P. Personalized Medical Devices. 4 Units.
Introduces students to fundamental aspects of medical devices and discusses therapeutic as well as diagnostic devices. Basic aspects of microfluidics and biology critical to personalized medical systems are studied. Typical FDA approval pathways for medical devices are presented.

Same as MAE 204P.

Restriction: Master of Engineering students only.

Concurrent with BME 204P.

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 211P. 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.

Prerequisite: Recommended: Undergraduate-level knowledge of system software (e.g. EECS 111) and organization of digital computers (e.g. UCI EECS 112).

Restriction: Master of Engineering students only. 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 213P. 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.

Prerequisite: Recommended: Undergraduate-level knowledge of organization of digital computers (e.g. EECS 112 and EECS 112L).

Restriction: Master of Engineering students only. 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 215P. 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.

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

EECS 216. Advanced Application of Algorithms. 4 Units.
Medium-sized group and individual programming project. Topics include specification requirements documentation, practical implementation of algorithms, and testing/verification of design.

Prerequisite: Recommended: Undergraduate course work in engineering data structures and algorithms.

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 217P. 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.

Prerequisite: Recommended: Undergraduate-level knowledge of organization of digital computers (e.g. EECS 112).

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

EECS 220P. 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 213P. EECS 213P with a grade of B- or better

Restriction: Graduate students only. Master of Engineering 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. EECS 211 with a grade of B- or better. EECS 213 with a grade of B- or better

Restriction: Graduate students only.

EECS 223P. 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 211P and EECS 213P. EECS 211P with a grade of B- or better. EECS 213P with a grade of B- or better

Restriction: Graduate students only. Master of Engineering 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 CS 260. EECS 215 with a grade of B- or better. CS 260 with a grade of B- or better

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 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 230P. Introduction to Machine Learning. 4 Units.
Introduces fundamental concepts in programming and machine learning. The goal is to provide an accessible introduction to the field of machine learning and related techniques for students with a wide variety of engineering degrees.

Same as BME 230P, CEE 230P, ENGR 230P, MAE 230P.

Restriction: Master of Engineering students only.

EECS 231. Advanced System Security. 4 Units.
Advanced study about system security. Topics include software vulnerabilities (buffer overflow), vulnerability discovery (fuzzing), network security, side-channel analysis (power analysis and micro-architecture attacks), machine-learning security, IoT security, and privacy (differential privacy).

Restriction: Graduate students only.

EECS 232. Data Privacy. 4 Units.
Presents data privacy in the digital age from multiple perspectives, including theoretical frameworks for privacy; tracking practices and privacy-enhancing technologies in various application domains; and data protection laws and policy.

Prerequisite: Recommended: Students should have familiarity with networking (web/HTTP, DNS, mobile devices) (EECS 148 or equivalent), probability (EECS 55 or equivalent), and programming in python (EECS 12 or equivalent) at the undergraduate level.

Restriction: Graduate students only.

EECS 240. Random Processes. 4 Units.
Extensions of probability theory to random variables varying with time. General properties of stochastic processes. Convergence. Estimation, including nonlinear and linear minimum mean square error and maximum likelihood. Spectral density and linear filters. Poisson processes and discrete-time Markov chains.

Restriction: Graduate students only.

EECS 240P. Random Processes. 4 Units.
Extensions of probability theory to random variables varying with time. General properties of stochastic processes. Convergence. Estimation, including nonlinear and linear minimum mean square error and maximum likelihood. Spectral density and linear filters. Poisson processes and discrete-time Markov chains.

Prerequisite: Recommended: Knowledge of engineering probability (e.g. EECS 55).

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

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

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

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

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. EECS 241A with a grade of B- or better

Restriction: Graduate students only.

EECS 241BP. 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 241AP. EECS 241AP with a grade of B- or better

Restriction: Graduate students only. Master of Engineering 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 240 with a grade of B- or better

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. EECS 240 with a grade of B- or better

Restriction: Graduate students only.

EECS 244. Wireless Communications. 4 Units.
Introduction to wireless communications systems. Wireless channel modeling. Single carries, spread spectrum, and multi-carrier wireless modulation schemes. Diversity techniques. Multiple-access schemes. Transceiver design and system level tradeoffs. Brief overview of GSM, CDMA, (IS-95) and 2.5, 3G cellular schemes.

Prerequisite: EECS 241B. EECS 241B with a grade of B- or better

Restriction: Graduate students only.

EECS 244P. Wireless Communications. 4 Units.
Introduction to wireless communications systems. Wireless channel modeling. Single carries, spread spectrum, and multi-carrier wireless modulation schemes. Diversity techniques. Multiple-access schemes. Transceiver design and system level tradeoffs. Brief overview of GSM, CDMA, (IS-95) and 2.5, 3G cellular schemes.

Prerequisite: EECS 241BP. EECS 241BP with a grade of B- or better

Restriction: Graduate students only. Master of Engineering 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.
Network architecture of the Internet, telephone networks, cable networks, and cell phone networks. Network performance models. Network performance models. Advanced concepts and implementations of flow and congestion control, addressing, internetworking, forwarding, routing, multiple access, streaming, and quality-of-service.

Prerequisite: EECS 148 or CS 132

Same as CS 232, NSYS 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 250P. 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.

Prerequisite: Recommended: Knowledge of digital signal processing (e.g. EECS 152A).

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

EECS 251A. Detection, Estimation, and Demodulation Theory. 4 Units.
Fundamentals of hypothesis testing and Bayes and Maximum Likelihood Estimation. ARMA and state variable models for random time series analysis. Wiener and Kalman filtering and prediction. Adaptive algorithms for identification and tracking of parameters of time-varying models.

Prerequisite: EECS 240. EECS 240 with a grade of B- or better

EECS 251B. Detection, Estimation, and Demodulation Theory. 4 Units.
Fundamentals of hypothesis testing and Bayes and Maximum Likelihood Estimation. ARMA and state variable models for random time series analysis. Wiener and Kalman filtering and prediction. Adaptive algorithms for identification and tracking of parameters of time-varying models.

Prerequisite: EECS 240. EECS 240 with a grade of B- or better

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.
Formulation, solution, and analysis of linear programming and linear network flow problems. Simplex methods, dual ascent methods, interior point algorithms, and auction algorithms. Duality theory and sensitivity analysis. Shortest path, max-flow, assignment, and minimum cost flow problems.

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. EECS 267A with a grade of B- or better

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 270AP. 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.

Prerequisite: Recommended: Introductory knowledge of control systems (e.g. EECS 160A) and electronics (e.g. EECS 170C).

Restriction: Master of Engineering students only. 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. EECS 270A with a grade of B- or better

Restriction: Graduate students only.

EECS 270BP. 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 270AP. EECS 270AP with a grade of B- or better

Restriction: Graduate students only. Master of Engineering 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. EECS 270A with a grade of B- or better

Restriction: Graduate students only.

EECS 270D. Radio-Frequency Integrated Circuits and Systems. 4 Units.
Fundamental topics in radio-frequency (RF) integrated circuits and systems including basic concepts in RF circuits and systems, RF receiver and transmitter architectures, and RF core building blocks such as low-noise amplifiers (LNAs), RF mixers, and power amplifiers.

Prerequisite: EECS 270A. EECS 270A with a grade of B- or better

Restriction: Graduate students only.

EECS 270E. MM-Wave and Terahertz Circuits. 4 Units.
Discussion of the new methodologies, circuits, and systems developed at mm-wave and terahertz frequency ranges due to the growing interest in high speed communication and high frequency signal generation.

Restriction: Graduate students only.

EECS 272P. 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 270AP. EECS 270AP with a grade of B or better

Restriction: Master of Engineering students only. 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.
Fabrication and characterization techniques of electrical circuit elements at the nanometer scale. Quantized conductance, semiconductor quantum dots, single electron transistors, molecular wires, carbon nanotubes, self-assembly of nano-circuit elements, quantum methods of information processing.

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 MAE 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 MAE 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. EECS 280A with a grade of B- or better

Restriction: Graduate students only.

EECS 280P. Advanced Engineering Electromagnetics I. 4 Units.
Stationary electromagnetic fields, Maxwell's equations, circuits and transmission lines, plane waves, guided waves, and radiation.

Prerequisite: Recommended: Knowledge of engineering electromagnetics (e.g. EECS 180A).

Restriction: Master of Engineering students only. 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 284P. RF Antenna Design . 4 Units.
Advanced transmission line design, radiation of electromagnetic waves, dipole antennas, antenna arrays, advanced antenna designs, and practical design considerations in communications systems. Course is supplemented by RF design tools and modeling.

Prerequisite: EECS 280AP. EECS 280AP with a grade of B- or better

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

Prerequisite: Undergraduate-level Engineering Electromagnetics I (e.g. EECS E80A).

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

EECS 286. Fabrication of Biomedical and Wearable Microdevices. 4 Units.
Covers preliminary details on prototyping and fabrication techniques for biomedical and wearable microdevices. Fabrication and behavior of modern biomed device materials such as hydrogel, PDMS, biopolymer, smart materials, and their uses are introduced.

Prerequisite: Required: Knowledge of undergraduate-level basic physics.

Restriction: Graduate students only.

EECS 287. Micro/Nano Biotechnology and Biosensing: Fundamentals, Designs, and Applications. 4 Units.
Provides insight into the current topics in Micro/Nanoscience, Micro/Nanotechnology fundamentals, and their modern-day applications in life sciences. Focus is on Micro/Nanodevices; Sensors' fundamentals; NanoBioSensors; Microfluidics; Micro/Nanofabrication, detection system-level characterization; performance determination; solid-state materials; and more.

Restriction: Graduate students only.

EECS 289. Bioinstrumentation. 4 Units.
Introduces instrumentation used in biomedical research, clinical medicine, and health monitoring. Interfacing of bioelectronics and biomedical sensing are taught with the most updated methods. The integration of bioinstrumentation with data science and cloud computing are introduced.

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.

Repeatability: Unlimited as topics vary.

Restriction: Graduate students only.

EECS 295P. Special Topics in Electrical Engineering and Computer Science. 4 Units.
Studies in selected areas of Electrical Engineering. Topics addressed vary each quarter.

Repeatability: Unlimited as topics vary.

Restriction: Master of Engineering students only. 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: AP Chemistry or SAT Subject Chemistry or SAT Mathematics or ACT Mathematics. AP Chemistry with a minimum score of 3. SAT Subject Chemistry with a minimum score of 600. SAT Mathematics with a minimum score of 600. ACT Mathematics with a minimum score of 27. A score of 85 or higher on the Engineering Chemistry Placement Exam (fee required) is also accepted.

Overlaps with CHEM 1A.

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

(II)

ENGR 7A. Introduction to Engineering I. 2 Units.
Introduction to engineering disciplines and the design process. Students enrolled in the online lecture also attend a three-hour lab on campus. Materials fee.

(Design units: 1)

Grading Option: In Progress (Letter Grade with P/NP).

Restriction: Lower-division students only. School of Engineering students have first consideration for enrollment.

ENGR 7B. Introduction to Engineering II. 2 Units.
Introduction to engineering disciplines and the design process. Students enrolled in the online lecture also attend a three-hour lab on campus. Materials fee.

(Design units: 2)

Prerequisite: ENGR 7A

Restriction: Lower-division students only. School of Engineering students have first consideration for enrollment.

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 PHYS 7C

Same as CEE 30, MAE 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. Materials fee.

(Design units: 0)

Prerequisite: (ENGR 1A or CHEM 1A or CHEM H2A) and PHYS 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 PHYS 7C

Same as CEE 80, MAE 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 and Engr 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)

Grading Option: Workload Credit Letter Grade with P/NP.

Repeatability: Unlimited as topics vary.

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

ENGR 113. Introduction to STEM Education Research. 4 Units.
Introduces students to education research and topics studied in STEM education. Enables students to develop research questions, participate in research projects, design and utilize research tools, and contribute to STEM education research products.

Same as BIOL 105.

Restriction: Upper-division students only. School of Engineering students have first consideration for enrollment.

ENGR 150. Mechanics of Structures. 4 Units.
Introduction to mechanics of materials. Topics include stresses and strains, axial and torsional loading, bending, shear, combined loading, stress and strain transformation, failure theories, beam deflection, and buckling.

(Design units: 2)

Prerequisite: (CEE 30 or ENGR 30 or MAE 30) and MATH 3A

Same as MAE 150.
Overlaps with CEE 150.

Restriction: Mechanical Engineering Majors have first consideration for enrollment. Aerospace Engineering Majors have first consideration for enrollment. Chemical Engineering Majors have first consideration for enrollment. Materials Science and Engr 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.
Learn the theory and practice of entrepreneurship and intrapreneurship. Covers positioning an idea, establishing the value propositions and benefits case, going to market strategy, creating an execution plan, and raising funds. Concepts are applied to a real-world venture project.

(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. Graduating seniors with an application on file have first consideration.

(Ib)

ENGR 191. Curricular Practical Training. 1 Unit.
Practical training under an industry mentor in a technical field corresponding to students' area of interest.

Grading Option: Pass/no pass only.

Repeatability: May be repeated for credit unlimited times.

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 Collegium students only.

(Ib)

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 Collegium students only.

ENGR 201P. Engineering Leadership and Entrepreneurship: Innovation. 4 Units.
Teaches concepts on how to develop innovate/disruptive ideas through actual delivery and adoption. Focuses on the critical thinking skills, the process of developing an idea into a product/service, and teaching a framework to foster adoption of the idea and product.

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

ENGR 202P. Engineering Leadership and Entrepreneurship: Build. 4 Units.
Learn how to build an executable plan to transform an idea into a product. Learn how to construct a go-to market plan, raise funds for building the product, and leverage ecosystem resources to fill in resource gaps.

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

ENGR 203P. Engineering Leadership and Entrepreneurship: Launch. 4 Units.
Understand how to build an actual product. Learn about prototyping and basic project management skills. Learn a framework on when to pivot for course corrections. Identify how to define outcome metrics and measure progress as the product is launched.

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

ENGR 207P. People Management and Communication. 4 Units.
Students gain knowledge on the strategies to effectively manage people. This includes improving recruitment and retention, training, managing conflicts, motivating people, giving feedback, and effective communication to manage each direct report.

Restriction: Master of Engineering students only.

ENGR 210P. Capstone Project . 4 Units.
Students are required to complete a project that deals with a specific emphasis of their Master of Engineering concentration/specialization.

Repeatability: May be taken for credit 4 times.

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

ENGR 211P. M.Eng Proseminar.
Provides students in the Master of Engineering program with information and.

Grading Option: Satisfactory/unsatisfactory only.

Repeatability: May be taken for credit 3 times.

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

ENGR 230P. Introduction to Machine Learning. 4 Units.
Introduces fundamental concepts in programming and machine learning. The goal is to provide an accessible introduction to the field of machine learning and related techniques for students with a wide variety of engineering degrees.

Same as BME 230P, CEE 230P, EECS 230P, MAE 230P.

Restriction: Master of Engineering students only.

ENGR 231P. Robotics and Controls. 4 Units.
Covers basic aspects of robotic and mechatronic design, including motor and sensor selection, control strategies, finite state machines, and implementation of advanced feedback control laws.

Same as MAE 231P.

Restriction: Master of Engineering students only.

ENGR 233P. Additive Manufacturing. 4 Units.
Covers the key concepts of Additive Manufacturing (AM, aka 3D printing), including historical perspectives, the general AM process chain, an overview of available AM technologies, materials for AM, and design strategies for AM.

Restriction: Master of Engineering students only.

ENGR 234P. Advanced Manufacturing and Design. 4 Units.
An in-depth knowledge of manufacturing processes with focus on the fundamentals of materials processing (heat flow, mass flow, fluid flow, etc.). Processing fundamentals that apply to the three main classes of engineering materials: metals, ceramics, and polymers.

Restriction: Master of Engineering students only.

ENGR 235P. Engineering Design and Simulation: Tools and Process. 4 Units.
Practical techniques and use of industry tools that improve the engineering design process by simulating the performance of design options prior to the costly steps of prototyping and manufacturing are covered. Applicable to a wide variety of engineering disciplines.

Same as MAE 235P.

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

ENGR 252P. 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.

Same as MAE 252P.

Restriction: Graduate students only. Master of Engineering 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.
Learn the theory and practice of entrepreneurship and intrapreneurship. Covers positioning an idea, establishing the value propositions and benefits case, going to market strategy, creating an execution plan, and raising funds. Concepts are applied to a real-world venture project.

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

Concurrent with ENGR 180.

ENGR 290. Developing Teaching Excellence. 4 Units.
Introduces the Scholarship of Teaching and Learning (SoTL) as it applies to Engineering Education. Focuses on how teaching practice can be guided by the research literature on teaching and learning.

Restriction: Graduate students only.

ENGR 290P. M.Eng Internship. 1-4 Units.
Students go through practical training under an industry mentor in a technical field corresponding to their area of interest.

Grading Option: Satisfactory/unsatisfactory only.

Repeatability: May be repeated for credit unlimited times.

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

ENGR 291. Internship. 1 Unit.
Practical training under an industry mentor in a technical field corresponding to the student's area of interest.

Grading Option: Satisfactory/unsatisfactory only.

Repeatability: May be repeated for credit unlimited times.

Restriction: Graduate students only.

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 295P. Special Topics in Master of Engineering. 4 Units.
Studies in selected areas of Master of Engineering. Topics addressed vary each quarter.

Repeatability: Unlimited as topics vary.

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

ENGR 298P. M.Eng Individual Project. 1-8 Units.
Supervised independent project for Master of Engineering students under the direction of the selected faculty member.

Grading Option: Satisfactory/unsatisfactory only.

Repeatability: May be repeated for credit unlimited times.

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

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.

Materials Science and Engineering Courses

MSE 60. Laboratory in Synthesis and Characterization of Materials. 4 Units.
Synthesis and characterization of ceramic, polymer, and semiconductor materials. Connect the process, structure, properties, and performance to materials science knowledge in a hands-on laboratory setting. Materials fee.

Prerequisite: ENGR 54 and CHEM 1C

Restriction: Materials Science and Engr Majors have first consideration for enrollment.

MSE 69. 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.

Prerequisite: PHYS 7D and PHYS 7E and (MATH 3A or ICS 6N) and MATH 3D and ENGR 54

Restriction: Materials Science and Engr Majors have first consideration for enrollment.

MSE 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.

Prerequisite: (ENGR 1A or CHEM 1A or CHEM H2A) and ENGR 54 and MSE 69

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

Concurrent with MSE 241.

MSE 142. Synthesis and Properties of Biological, Biomimetic, and Bio-Inspired Materials. 4 Units.
Synthesis of biological materials, including self-assembly and biomineralization, and translational processing to engineered materials via additive manufacturing, freeze casting, and other methods. Subsequent functional properties of these materials are reviewed.

Prerequisite: ENGR 54 and MSE 165C

Restriction: Materials Science and Engr Majors have first consideration for enrollment.

MSE 151. Polymeric Materials. 4 Units.
An introduction to physical aspects of polymers, including polymer molecular size and configuration, solution and bulk phase structural properties, mechanical properties including viscoelasticity and rheology, polymer synthesis methods, characterization techniques, processing methods, and examples from existing and emerging polymeric materials.

Prerequisite: ENGR 54 and (MSE 165A or CBE 40C or MAE 91)

Restriction: Materials Science and Engr Majors have first consideration for enrollment.

MSE 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.

Prerequisite: ENGR 54

Same as MAE 156.

Restriction: Mechanical Engineering Majors have first consideration for enrollment. Materials Science and Engr Majors have first consideration for enrollment. Aerospace Engineering majors have second consideration for enrollment.

MSE 155L. Mechanical Behavior Laboratory. 2 Units.
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.

Corequisite: MSE 155
Prerequisite: ENGR 54

Restriction: Materials Science and Engr Majors have first consideration for enrollment.

MSE 158. Ceramic Materials for Sustainable Energy. 4 Units.
A technical elective for students interested in materials. Topics covered include structure and properties of ceramic materials, and design for sustainable energy applications.

Prerequisite: ENGR 54

Restriction: Materials Science and Engr Majors have first consideration for enrollment. Chemical Engineering majors have second consideration for enrollment.

MSE 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, interfacint techniques, programming strategies, data analysis, data storage, safeguard procedures.

Restriction: Materials Science and Engr Majors have first consideration for enrollment. Chemical Engineering majors have second consideration for enrollment.

MSE 164. X-ray Diffraction, Electron Microscopy, and Microanalysis. 4 Units.
Material characterization using X-ray diffraction and scanning electron microscopy (SEM). Topics include X-ray diffraction and analysis; SEM imaging and microanalysis.

Prerequisite: ENGR 54 and PHYS 7D

Restriction: Materials Science and Engr Majors have first consideration for enrollment.

MSE 164L. X-ray Diffraction, Electron Microscopy, and Microanalysis Lab. 1 Unit.
Material characterization using X-ray diffraction and scanning electron microscopy (SEM). Topics include X-ray diffraction and analysis; SEM imaging and microanalysis. Materials fee.

Prerequisite: ENGR 54 and PHYS 7D

Restriction: Materials Science and Engr Majors only.

MSE 165A. 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.

Prerequisite: CHEM 1C and PHYS 7C

Restriction: Materials Science and Engr Majors have first consideration for enrollment.

MSE 165B. Diffusion and Heat Transport in Materials. 4 Units.
Examines how kinetics affect materials development, behavior, and processing. Highlights the ways in which kinetics and diffusion are key to designing materials processing and heat treating strategies, with examples in various applied topics.

Prerequisite: ENGR 54 and (MSE 165A or CBE 40C or MAE 91). ENGR 54 with a grade of C- or better. MSE 165A with a grade of C- or better

Restriction: Materials Science and Engr Majors have first consideration for enrollment.

MSE 165C. Materials Kinetics and Phase Transformations. 4 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.

Prerequisite: ENGR 54 and (MSE 165A or CBE 40C or MAE 91) and (MSE 165B or BME 150 or MAE 120 or (CBE 120B and CBE 120C)). MSE 165A with a grade of C- or better

Restriction: Materials Science and Engr Majors have first consideration for enrollment.

MSE 165CL. Laboratory in Materials Kinetics and Phase Transformations. 2 Units.
Covers topics of practical application of the kinetics of solid state reactions, reactions at interfaces, and the thermodynamics and kinetics of phase transformations to common materials systems.

Prerequisite: ENGR 54 and (MSE 165B or (CBE 120B and CBE 120C) or MAE 120). MSE 165B with a grade of C- or better

Restriction: Materials Science and Engr Majors only.

MSE 171. Green Engineering: Theory and Practice. 4 Units.
Methods and impacts of selecting alternative technologies, processes, materials, chemicals, to reduce pollution, waste, and use of toxic substances, thereby creating “green,” environmentally responsible, sustainable solutions. Topics include environmental regulations, recycling, life-cycle assessment, economic analysis, design, green chemistry, and toxicology.

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

MSE 174. Composite Materials Design. 4 Units.
Introduction to fiber-reinforced composites for mechanical applications. Properties of reinforcing fibers. Manufacture of fibers and composites. Micromechanics of fiber composites. Strength criteria and failure modes. Macromechanics in design of laminated composite structures.

Prerequisite: ENGR 54 and ENGR 150

Restriction: Materials Science and Engr Majors have first consideration for enrollment.

MSE 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.

Prerequisite: ENGR 54

Restriction: Materials Science and Engr Majors have first consideration for enrollment. Chemical Engineering majors have second consideration for enrollment.

MSE 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: (CBE 110 or MSE 165C) and (MSE 141 or MSE 69)

Same as CBE 183.

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

Concurrent with MSE 276 and CBE 283.

MSE 178. Fundamentals of Materials Processing: How are Materials Processed to Make Things?. 4 Units.
In-depth knowledge of manufacturing processes (from liquid, solid, and vapor phases) with focus on the fundamentals of materials processing – transport and mechanical forces. Processing fundamentals that apply to the three main classes of engineering materials: metals, ceramics, and polymers.

Prerequisite: ENGR 54

Restriction: Materials Science and Engr Majors have first consideration for enrollment.

Concurrent with MSE 278.

MSE 187. Essential Skills in Engineering. 4 Units.
A 10-week immersion in the essential skills that are the anchors for being a supreme professional. Designed with many case studies and complemented with appearances by successful industry leaders.

Restriction: Materials Science and Engr Majors have first consideration for enrollment.

Concurrent with MSE 287.

MSE 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.

Prerequisite: ENGR 54 and MSE 155 and MSE 60 and MSE 165C

Grading Option: In Progress (Letter Grade with P/NP).

Restriction: Seniors only. Materials Science and Engr Majors only. MSE 189A, MSE 189B, and MSE 189C must be taken in the same academic year.

MSE 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.

Prerequisite: MSE 189A

Grading Option: In Progress (Letter Grade with P/NP).

Restriction: Seniors only. Materials Science and Engr Majors only. MSE 189A, MSE 189B, and MSE 189C must be taken in the same academic year.

MSE 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.

Prerequisite: MSE 189B

Restriction: Seniors only. Materials Science and Engr Majors only. MSE 189A, MSE 189B, and MSE 189C must be taken in the same academic year.

MSE 190. Materials Selection and Design. 4 Units.
Meaning and phases of design; design considerations; properties of engineering materials; materials property charts; materials selection; process selection; multi-constraint and multi-objective design. Selection of shape in mechanical components. Designing with hybrid materials: challenges and opportunities. Environmental considerations; case studies.

Prerequisite: ENGR 54 and ENGR 150

Restriction: Materials Science and Engr Majors have first consideration for enrollment.

MSE 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.

Prerequisite: ENGR 54

Restriction: Materials Science and Engr Majors have first consideration for enrollment.

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

Prerequisite: Prerequisites vary.

Repeatability: Unlimited as topics vary.

MSE 197. Materials Science and Engineering Internship. 2-12 Units.
Students majoring in MSE may receive credit for an approved internship, working at a company under the supervision of an industry mentor and a faculty advisor. Enables students to gain valuable experience in a professional setting and enhance their skills.

Grading Option: Pass/no pass only.

Repeatability: May be taken for credit 3 times.

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

Repeatability: May be repeated for credit unlimited times.

Restriction: Upper-division students only.

MSE 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.

Repeatability: May be taken for credit for 8 units.

Restriction: Materials Science and Engr Majors only.

MSE 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.

Grading Option: Pass/no pass only.

Repeatability: May be repeated for credit unlimited times.

MSE 200. Structure of Materials. 4 Units.
Foundations and framework for understanding, quantifying and characterizing structure of crystalline and non-crystalline materials. Focuses on using mathematical and graphical descriptors of structural arrangement, symmetry, short/long-range order, tensors in real space and reciprocal space, fundamentals of diffraction-based materials analysis.

Prerequisite: Recommended: Graduate standing in Materials Science and Engineering, Chemical Engineering, or related educational background (physical sciences or engineering), along with an introductory course in materials science (E54 or equivalent).

Restriction: Graduate students only.

MSE 201A. Critical Analysis and Technical Communication I. 2 Units.
Develop an understanding of the process to conduct research. Topics include performing analytical analysis of the scientific literature, formation of a hypothesis, defining investigations to validate hypothesis, communicating analysis in written form, writing a research proposal.

Restriction: Graduate students only.

MSE 201B. Critical Analysis and Technical Communication II. 2 Units.
Develop oral presentation skills and skills to understand significance of published research. Topics include performing critical and analytical analysis of the scientific literature, connecting core course content with experimental/theoretical methods in the scientific literature, and communicating analysis in oral form.

Prerequisite: MSE 201A. MSE 201A with a grade of B- or better

Restriction: Graduate students only.

MSE 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.

Prerequisite: MSE 200. MSE 200 with a grade of B- or better

Restriction: Graduate students only.

MSE 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.

Prerequisite: MSE 200 and MSE 205. MSE 200 with a grade of B- or better. MSE 205 with a grade of B- or better

Restriction: Graduate students only.

Concurrent with MSE 141.

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

Prerequisite: Prerequisites vary.

Repeatability: Unlimited as topics vary.

Restriction: Graduate students only.

MSE 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 visoelasticity, rheology, and processing.

Restriction: Graduate students only.

MSE 255A. Design with Ceramic Materials. 4 Units.
Dependence of ceramic properties on bonding, crystal structure, defects, and microstructure. Ceramic manufacturing technology. Survey of physical properties. Strength, deformation, and fracture of ceramics. Mechanical design with brittle, environment-sensitive materials exhibiting time-dependent strengths.

Prerequisite: ENGR 54

Restriction: Graduate students only.

MSE 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.

MSE 256B. Fracture of Engineering Materials. 4 Units.
Fracture mechanics and its application to engineering materials. Elastic properties of cracks, the stress intensity factor, the crack tip plastic zone, the J integral approach, fracture toughness testing, the crack tip opening displacement, fracture at high temperatures, fatigue crack growth.

Restriction: Graduate students only.

MSE 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: MSE 200. MSE 200 with a grade of B- or better

Restriction: Graduate students only.

MSE 262. Grain Boundaries and Interfaces in Nanocrystalline Materials. 4 Units.
Structure and character of grain boundaries and interfaces in solids including nanocrystalline materials. Role of grain boundaries in chemical segregation, fracture, deformation, creep, conductivity, diffusion, and grain growth. Experimental techniques and computational methods used to characterize and model grain boundaries.

Prerequisite: MSE 200. MSE 200 with a grade of B- or better

MSE 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: MSE 200. MSE 200 with a grade of B- or better

Restriction: Graduate students only.

MSE 265A. Materials Thermodynamics and Statistical Mechanics. 4 Units.
Topics related to classical and statistical thermodynamics applied.

Prerequisite: MSE 200. MSE 200 with a grade of B- or better

Restriction: Graduate students only.

MSE 265B. Phase Transformations and Kinetic Phenomena in Materials. 4 Units.
Topics related to phase transitions in materials including treatments of diffusion, nucleation and growth, dynamics of diffusional and diffusion-less phase transitions, solidification, and capillarity driven kinetics.

Prerequisite: MSE 265A. MSE 265A with a grade of B- or better

Restriction: Graduate students only.

MSE 267. 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 MBB 268, PHYS 268.

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

MSE 271. Green Engineering: Theory and Practice. 4 Units.
Methods and impacts of selecting alternative technologies, processes, materials, chemicals, to reduce pollution, waste, and use of toxic substances, thereby creating “green,” environmentally responsible, sustainable solutions. Topics include environmental regulations, recycling, life-cycle assessment, economic analysis, design, green chemistry, and toxicology.

Restriction: Graduate students only.

MSE 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: MSE 200. MSE 200 with a grade of B- or better

MSE 276. 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.

Same as CBE 283.

Restriction: Graduate students only.

Concurrent with MSE 176 and CBE 183.

MSE 287. Essential Skills in Engineering. 4 Units.
A 10-week immersion in the essential skills that are the anchors for being a supreme professional. Designed with many case studies and complemented with appearances by successful industry leaders.

Restriction: Graduate students only.

Concurrent with MSE 187.

MSE 295. Seminar in Engineering. 1-4 Units.
Seminars by individual faculty in major fields of interest.

Grading Option: Satisfactory/unsatisfactory only.

Repeatability: Unlimited as topics vary.

Restriction: Graduate students only.

MSE 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 in Engineering.

Repeatability: May be repeated for credit unlimited times.

Restriction: Graduate students only.

MSE 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.

Repeatability: May be repeated for credit unlimited times.

Restriction: Graduate students only.

MSE 298. Seminars in Materials Science and Engineering. 2 Units.
Presentation of advanced topics and reports of current research efforts in Materials Science and Engineering.

Grading Option: Satisfactory/unsatisfactory only.

Repeatability: May be repeated for credit unlimited times.

Restriction: Graduate students only.

MSE 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.

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, numerical analysis, and data visualization with a high-level programming language such as MATLAB.

(Design units: 1)

Corequisite: MATH 2A
Prerequisite: MATH 2A or MATH 5A

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

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

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

(Design units: 0)

Corequisite: MATH 2D
Prerequisite: MATH 2D and PHYSICS 7C

Same as ENGRCEE 30, ENGR 30.

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

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

(Design units: 0.5)

Restriction: Mechanical Engineering Majors have first consideration for enrollment. Materials Science and Engr Majors 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 and Engr 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 CBE 40B.

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 and Engr Majors have first consideration for enrollment. Environmental Engineering Majors have first consideration for enrollment.

ENGRMAE 93. Topics in Design Project . 1-4 Units.
Early-stage design/hands-on experience for students, and allows them to participate alongside seniors in the design project.

(Design units: 1)

Repeatability: Unlimited as topics vary.

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

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

(Design units: 2)

Prerequisite: ENGRMAE 60 or EECS 70A

Restriction: Mechanical Engineering Majors have first consideration for enrollment. Aerospace Engineering Majors have first consideration for enrollment. Civil Engineering Majors have first consideration for enrollment. Materials Science and Engr Majors have first consideration for enrollment. Environmental Engineering Majors have first consideration for enrollment.

ENGRMAE 107. Fluid Thermal Science Laboratory. 4 Units.
Fluid and thermal engineering laboratory. Experimental analysis of fluid flow, heat transfer, and thermodynamic systems. Probability, statistics, and 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 units: 2)

Prerequisite: ENGRMAE 130B

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

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

(Design units: 2)

Prerequisite: ENGRMAE 115

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

ENGRMAE 112. Propulsion. 4 Units.
Application of thermodynamics and fluid mechanics to basic flow processes and cycle performance in chemical propulsion systems: gas turbines, ramjets, scramjets, and rockets. Introduction to electric and electromagnetic rocket thrusters, nuclear rockets, and solar sails.

(Design units: 1)

Prerequisite: ENGRMAE 130C

Restriction: Aerospace Engineering Majors have first consideration for enrollment. Mechanical Engineering majors have second 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 electrostatis accelerators, with emphasis in technologies (ion engines, Hall thrusters, and colloidal thrusters) belonging to the latter family.

(Design units: 1)

Prerequisite: ENGRMAE 112

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

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. Chemical Engineering majors have second consideration for enrollment.

Concurrent with ENGRMAE 214A.

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

(Design units: 2)

Prerequisite: ENGRMAE 91 or CBE 40B or ENGRMSE 65A

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

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

(Design units: 1)

Prerequisite: (ENGRMAE 91 or CBE 40B)

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

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

Concurrent with ENGRMAE 218.

ENGRMAE 119. Climate Solutions. 4 Units.
Introduction to climate change science and impacts on the health of people and the planet with a focus on the multi-dimensional aspects of solutions to the climate crisis.

Same as EARTHSS 179, UPPP 111.

Restriction: Upper-division students only.

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

(Design units: 0)

Prerequisite: ENGRMAE 130B

Overlaps with CBE 120B.

Restriction: Mechanical Engineering Majors have first consideration for enrollment. Aerospace Engineering Majors have first consideration for enrollment. Materials Science and Engr Majors have first consideration for enrollment.

ENGRMAE 130A. Fluid Dynamics I. 4 Units.
Fundamental concepts; fluid statics; kinematics; incompressible and compressible flows; Bernoulli's equation; control-volume analysis; conservation of mass, momentum, and energy; differential analysis; introduction to potential flow and viscous flow.

(Design units: 0)

Corequisite: (ENGRMAE 80 or ENGRCEE 80 or ENGR 80) and ENGRMAE 91 and MATH 2E
Prerequisite: PHYSICS 7C and MATH 2D and MATH 3D and (ENGRMAE 30 or ENGRCEE 30 or ENGR 30) and (ENGRMAE 80 or ENGRCEE 80 or ENGR 80). PHYSICS 7C with a grade of C- or better. MATH 2D with a grade of C- or better. MATH 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

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

ENGRMAE 130B. Fluid Dynamics II. 4 Units.
Analysis of viscous flows: stress-strain rate, fully developed laminar and turbulent flows. Review of thermodynamics, sound speed, stagnation properties. One dimensional isentropic and non-isentropic compressible flows. Normal and oblique shock waves. Two-dimensional supersonic isentropic flow.

(Design units: 1)

Prerequisite: ENGRMAE 130A

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

ENGRMAE 130C. Fluid Mechanics III. 4 Units.
Advanced topics in viscous and compressible flows. Viscous boundary layers, basic concepts in turbulent flow, separated flows, thermal transport, two-dimensional supersonic flow, shock polars, supersonic airfoils, conical flows.

Prerequisite: ENGRMAE 130B

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

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

(Design units: 0)

Prerequisite: ENGRMAE 130B. ENGRMAE 130B with a grade of C- or better

Restriction: Aerospace Engineering Majors only. Mechanical Engineering Majors only.

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

(Design units: 1)

Prerequisite: ENGRMAE 130A

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

ENGRMAE 136. Aerodynamics. 4 Units.
Advanced potential flow, vorticity, and circulation. Flow over aircraft wings and airfoils: Kutta-Joukowski theory, lift, moment, and drag. Flow similitude; three dimensional wing theory, compressibility, viscous effects. Source panel methods. Supersonic aerodynamics.

(Design units: 1)

Prerequisite: ENGRMAE 130B

Restriction: Mechanical Engineering Majors have first consideration for enrollment. Aerospace 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 or ENGRCEE 80 or ENGR 80) and (MATH 3A or I&C SCI 6N)

Restriction: Mechanical Engineering Majors have first consideration for enrollment. Materials Science and Engineering majors have second 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 or ENGRCEE 80 or ENGR 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 and Engr Majors have first consideration for enrollment.

ENGRMAE 148. Mechanics of Smart Structures. 4 Units.
Introduction to modeling, numerical simulation, design, and control of axial, torsional, and bending actuators. Fundamentals of shape-changing trusses, frames, and panels. Introduction to the behavior and modeling of smart materials such as shape memory alloys/polymers.

Prerequisite: ENGRMAE 150

Concurrent with ENGRMAE 248.

ENGRMAE 150. Mechanics of Structures. 4 Units.
Introduction to mechanics of materials. Topics include stresses and strains, axial and torsional loading, bending, shear, combined loading, stress and strain transformation, failure theories, beam deflection, and buckling.

(Design units: 2)

Prerequisite: (ENGRCEE 30 or ENGR 30 or ENGRMAE 30) and MATH 3A

Same as ENGR 150.
Overlaps with ENGRCEE 150.

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

ENGRMAE 150L. Mechanics of Structures Laboratory. 1 Unit.
Experimental techniques for the measurement of mechanical properties of materials and structures. Methods for load, displacement, and strain measurements. Tension, bending, compression tests. Determination of strength. Materials fee.

(Design units: 0)

Corequisite: ENGRMAE 150
Prerequisite: ENGRMAE 30 or ENGR 30 or ENGRCEE 30

Overlaps with ENGRCEE 150L.

Restriction: Mechanical Engineering Majors have first consideration for enrollment. Aerospace Engineering Majors have first consideration for enrollment. Materials Science and Engr Majors have first consideration for enrollment.

ENGRMAE 151A. Mechanical Engineering Design I. 4 Units.
Teaching and implementation of all phases of the engineering design process that begins with identifying needs, setting requirements, concept generation, and preliminary design. Emphasis on detailed engineering analysis and documentation for a small-team, open-ended design project.

(Design units: 3)

Corequisite: ENGRMAE 107
Prerequisite: ENGRMAE 106 and ENGRMAE 145 and ENGRMAE 150

Restriction: Seniors only. Mechanical Engineering Majors only.

ENGRMAE 151B. Mechanical Engineering Design II. 4 Units.
Manufacturing, diagnostics and quality, economics, ethics, and inclusivity. Continuation of the engineering design process with analysis and modeling, physical prototyping, testing, verification, and validation of solutions for the open-ended design project. Teamwork, project presentations, and documentation. Materials fee.

(Design units: 3)

Prerequisite: ENGRMAE 151A

Restriction: Seniors only. Mechanical 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: Mechanical Engineering Majors have first consideration for enrollment. Aerospace Engineering Majors have first consideration for enrollment. Materials Science and Engr 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)

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

Concurrent with ENGRMAE 253.

ENGRMAE 155. Composite Materials and Structures. 4 Units.
Micro and macro mechanical properties and failure mechanisms of lamina and laminates. Laminate theory, hygrothermal effects, failure analysis and design. Manufacturing methods, non-destructive evaluation, experimental characterization. Application of numerical modeling for analysis and design.

(Design units: 0)

Prerequisite: ENGR 54 and (ENGRMAE 150 or ENGRCEE 150 or ENGR 150)

Restriction: Mechanical Engineering Majors have first consideration for enrollment. Aerospace Engineering majors have second consideration for enrollment. Chemical Engineering majors have second consideration for enrollment. Civil Engineering majors have second consideration for enrollment. Materials Science and Engineering majors have second consideration for enrollment.

Concurrent with ENGRMAE 255.

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

(Design units: 2)

Prerequisite: ENGR 54

Same as ENGRMSE 155.

Restriction: Mechanical Engineering Majors have first consideration for enrollment. Materials Science and Engr Majors have first consideration for enrollment. Aerospace Engineering majors have second consideration for enrollment.

ENGRMAE 157. Lightweight Structures. 4 Units.
Mass minimization under stiffness, strength, and buckling constraints. Finite Element method and application to trusses. Three-dimensional bending. Thin-wall, composite, and functionally graded beams. Plates and shells, design of laminated and functionally graded plates. Stress analysis of aircraft components.

(Design units: 2)

Prerequisite: ENGR 150 or ENGRCEE 150 or ENGRMAE 150

Restriction: Aerospace Engineering Majors have first consideration for enrollment. Mechanical Engineering majors have second consideration for enrollment. Civil Engineering majors have second consideration for enrollment. Materials Science and Engineering majors have second consideration for enrollment.

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

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

(Design units: 4)

Prerequisite: ENGRMAE 112 and ENGRMAE 136 and ENGRMAE 158

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

ENGRMAE 163. Aviation Systems and the Environment. 4 Units.
Methods for analyzing aviation systems, flight and engine performance, and operations, and associated modern environmental challenges, including fuel burn, emissions, and noise are introduced. Analysis methods and technological and policy approaches for environmental impact mitigation examined.

Prerequisite: ENGRMAE 80 or ENGRMAE 91 or ENGRMAE 107

Restriction: Mechanical Engineering Majors only. Aerospace Engineering Majors only.

Concurrent with ENGRMAE 263.

ENGRMAE 164. Air Pollution and Control. 4 Units.
Sources, dispersion, and effects of air pollutants. Topics include emission factors, emission inventory, air pollution, meteorology, air chemistry, air quality modeling, impact assessment, source and ambient monitoring, regional control strategies.

(Design units: 2)

Prerequisite: (ENGRMAE 91 or CBE 40B) and ENGRMAE 130A

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

ENGRMAE 170. Introduction to Control Systems. 4 Units.
Feedback control systems. Modeling, stability, and systems specifications. Root locus, Nyquist, and Bode methods of analysis and design.

(Design units: 2)

Prerequisite: ENGRMAE 80 or ENGRCEE 80 or 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 and Engr Majors have first consideration for enrollment.

ENGRMAE 171. Digital Control Systems. 4 Units.
Methods for analysis and design of discrete-time control systems. Z-transforms, difference equations, discrete Fourier transforms. Sampling theorem and applications. Z-plane stability, frequency response. Digital controller design. Introduction to digital filters.

(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. Materials fee.

(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.
Equations of motion, linearization, stability derivatives, and longitudinal and lateral modes of motion. Handling qualities, sensors and actuators, and effects of various feedbacks on stability and performance. Stability augmentation. Autopilot design.

(Design units: 3)

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

ENGRMAE 182. Introduction to Machine Learning. 4 Units.
Fundamental principles necessary to understand statistical learning methods. Introduction to the R programming language. Mathematical foundation for various machine learning algorithms. Computer implementation.

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

(Design units: 4)

Prerequisite: MATH 3A or I&C SCI 6N

Restriction: Mechanical Engineering Majors have first consideration for enrollment.

ENGRMAE 184. Fundamentals of Experimental Design. 4 Units.
Review of statistics as applied to experimental research. Fundamentals and principles of statistical experimental design and analysis with emphasis on understanding and use of designed experiments, response surfaces, linear regression modeling, and process optimization.

(Design units: 1)

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

Concurrent with ENGRMAE 284.

ENGRMAE 185. Numerical Analysis in Mechanical and Aerospace Engineering. 4 Units.
Solution of mechanical and aerospace engineering equations by means of numerical methods. Errors in numerical analysis. Methods for solving systems of algebraic equations. Interpolation, integration and differentiation. Numerical solutions to differential equations. Introduction to Python and its scientific computing modules.

(Design units: 2)

Corequisite: MATH 2E
Prerequisite: (ENGRMAE 10 or EECS 10 or EECS 12 or BME 60B) and MATH 3D and MATH 2E

Overlaps with MATH 105A.

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

(Design units: 4)

Repeatability: May be taken for credit 3 times.

Restriction: Mechanical Engineering Majors have first consideration for enrollment.

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

(Design units: 1-4)

Repeatability: May be taken for credit for 12 units as topics vary.

Restriction: Seniors only. Mechanical Engineering Majors only.

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

(Design units: 1)

Repeatability: May be taken for credit for 12 units as topics vary.

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

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

(Design units: 1-4)

Repeatability: Unlimited as topics vary.

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

(Design units: 1-4)

Repeatability: May be repeated for credit unlimited times.

Restriction: Upper-division students only.

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

(Design units: 1-4)

Repeatability: May be taken for credit for 8 units.

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

(Design units: 1-4)

Grading Option: Pass/no pass only.

Repeatability: May be repeated for credit unlimited times.

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

Restriction: Graduate students only.

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

Restriction: Graduate students only.

ENGRMAE 202P. Professional Engineering Fundamentals. 4 Units.
The fundamentals of the core topics in mechanical and aerospace engineering are first reviewed and then integrated and applied in the context of engineered systems.

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

ENGRMAE 204P. Personalized Medical Devices. 4 Units.
Introduces students to fundamental aspects of medical devices and discusses therapeutic as well as diagnostic devices. Basic aspects of microfluidics and biology critical to personalized medical systems are studied. Typical FDA approval pathways for medical devices are presented.

Same as EECS 204P.

Restriction: Master of Engineering students only.

Concurrent with BME 204P.

ENGRMAE 205. Perturbation Methods in Engineering. 4 Units.
Asymptotic Expansions of integrals. Regular and singular perturbations. Perturbation methods for ordinary and partial differential equations. Matched asymptotic expansions. Multiple-scale asymptotic expansion schemes. Not offered every year.

Prerequisite: ENGRMAE 200A and ENGRMAE 200B. ENGRMAE 200A with a grade of B- or better. ENGRMAE 200B with a grade of B- or better. Knowledge of linear differential equations.

Restriction: Graduate students only.

ENGRMAE 205P. Model-Based Engineering: Systems and Design. 4 Units.
Engineering design, systems engineering, and product lifecycle management. Model-based approaches and modeling for the digital twin. Software tools and application to the design of a complete product from problem definition to production.

Restriction: Master of Engineering students only.

ENGRMAE 206. Nonlinear Optimization Methods. 4 Units.
Numerical methods for constrained and unconstrained optimization. Necessary and sufficient conditions for optimimality. Conjugate gradient, variable metric algorithms. Gradient projection, penalty functions, and Lagrange methods. Not offered every year.

Prerequisite: ENGRMAE 200A. ENGRMAE 200A with a grade of B- or better

Restriction: Graduate students only.

ENGRMAE 209P. Energy Efficiency in the Built Environment. 4 Units.
Energy and power for the built environment; building energy modeling; heat transfer and losses; heating and cooling cycles; control hardware and software; carbon neutrality, optimization.

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

ENGRMAE 210. Advanced Fundamentals of Combustion. 4 Units.
Premixed, nonpremixed, and heterogenous reactions, with emphasis on kinetics, thermal ignition, turbulent flame propogation, detonations, explosions, flammability limits, diffusion flame, quenching, flame stabilization, and particle and spray combustion. Not offered every year.

Prerequisite: ENGRMAE 224 or ENGRMAE 230B

Restriction: Graduate students only.

ENGRMAE 210P. Fundamentals and Applications of Combustion. 4 Units.
Premixed, nonpremixed, and heterogenous reactions, with emphasis on kinetics, thermal ignition, turbulent flame propogation, detonations, explosions, flammability limits, diffusion flame, quenching, flame stabilization, and particle and spray combustion.

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

ENGRMAE 211P. Energy Storage Systems and Technology. 4 Units.
Basic principles, design, and operation of energy storage systems and technology including lithium ion battery systems for transportation and stationary applications, for flow batteries (e.g., vanadium redox, sodium sulfur), and for reversible fuel cell electrolyzer systems and hydrogen energy storage.

Prerequisite: Required: Undergraduate-level knowledge of applied engineering thermodynamics.

Restriction: Master of Engineering students only. 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 212P. 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 are also covered.

Restriction: Master of Engineering students only. 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. ENGRMAE 214A with a grade of B- or better

Restriction: Graduate students only.

ENGRMAE 214C. PEM Fuel Cells . 4 Units.
In-depth introduction to the fundamental principles of PEM fuel cells, including thermodynamics, kinetics, transport, cold start, manufacturing, and experiment.

Prerequisite: ENGRMAE 214A. ENGRMAE 214A with a grade of B- or better

Restriction: Graduate students only.

ENGRMAE 214P. 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: Master of Engineering students only. 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 217P. 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: Master of Engineering students only. 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 218P. 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: Master of Engineering students only. Graduate students only.

ENGRMAE 219P. 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.

Prerequisite: Required: Knowledge of applied engineering thermodynamics.

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

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.
Fundamental convective heat transfer for various cases, including flow conditions, flow phases, and boundary conditions. Analysis of heat convection by exact, approximate solutions, and similarity solutions. Boundary layer theory and equations.

Prerequisite: ENGRMAE 230B. ENGRMAE 230B with a grade of B- or better

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. ENGRMAE 230A with a grade of B- or better

Restriction: Graduate students only.

ENGRMAE 224. Advanced Transport Phenomena. 4 Units.
Fundamentals of transport phenomena. Covers the subjects of conservation equations, dimensionless numbers, fundamentals of diffusion, perturbation methods, ion transport, two-phase transport, and interfacial phenomena.

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 229P. Nanoscale Materials for Modern Electronics. 4 Units.
Introduction to design and synthesis of nanomaterials. Topics include thermal and liquid transport in materials systems, phase change heat transfer physics, and mechanical properties in materials systems.

Prerequisite: Required: Undergraduate-level knowledge of heat transfer.

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

ENGRMAE 230A. Inviscid Incompressible Fluid Mechanics I. 4 Units.
Equations of motion. Vector notation. Flow kinematics. Potential flow and complex potential. Vorticity and circulation. Bernoulli's theorem. Crocco's theorem. Conformal, Joukowski, and Schwarz-Christoffel transformations.

Restriction: Graduate students only.

ENGRMAE 230B. Viscous Incompressible Fluid Mechanics II. 4 Units.
Review of mass, momentum, energy equations. Stress tensor, constitutive relations. Laminar flows. Stokes and Oseen flows. Self-similarity. Boundary layer theory: thin-layer approximation, Falkner-Skan, Blasius solutions, integral methods. Jet, wake, cavity flows. Introduction to turbulence: instability, Reynolds averaging, mixing length.

Restriction: Graduate students only.

ENGRMAE 230C. Compressible Fluid Dynamics. 4 Units.
One-dimensional unsteady flow; Riemann invariants, acoustics, shock tube. Two-dimensional flow: shock polars, linear theory, similarity rules, method of characteristics. Three dimensional flow: slender-body theory. Effects of viscosity and conductivity: laminar boundary layer, Crocco-Busemann relations.

Prerequisite: ENGRMAE 230A or ENGRMAE 230B. ENGRMAE 230A with a grade of B- or better. ENGRMAE 230B with a grade of B- or better

Restriction: Graduate students only.

ENGRMAE 230D. Theoretical Foundations of Fluid Mechanics. 4 Units.
Well-posed problems and boundary, initial, and interface conditions; strong and weak solutions. Similarity, perturbation theory and limit behavior, bifurcations. Dispersive and nondispersive wave propagation, acoustics, ship waves, internal gravity waves, water waves. Vortices: mutual interactions and stability. Jets, wakes, cavities.

Prerequisite: ENGRMAE 230A and ENGRMAE 230B. ENGRMAE 230A with a grade of B- or better. ENGRMAE 230B with a grade of B- or better

Restriction: Graduate students only.

ENGRMAE 230P. Introduction to Machine Learning. 4 Units.
Introduces fundamental concepts in programming and machine learning. The goal is to provide an accessible introduction to the field of machine learning and related techniques for students with a wide variety of engineering degrees.

Same as BME 230P, ENGRCEE 230P, EECS 230P, ENGR 230P.

Restriction: Master of Engineering students only.

ENGRMAE 231. Fundamentals of Turbulence. 4 Units.
Phenomenon of turbulence. Reynolds equations. Dynamics of turbulence. Free turbulent shear flows. Wall-bounded turbulent shear flows. Turbulent transport of scalar quantities. Spectral dynamics. Mathematical models of turbulence.

Prerequisite: ENGRMAE 230A and ENGRMAE 230B. ENGRMAE 230A with a grade of B- or better. ENGRMAE 230B with a grade of B- or better

Restriction: Graduate students only.

ENGRMAE 231P. Robotics and Controls. 4 Units.
Covers basic aspects of robotic and mechatronic design, including motor and sensor selection, control strategies, finite state machines, and implementation of advanced feedback control laws.

Same as ENGR 231P.

Restriction: Master of Engineering students only.

ENGRMAE 233. Turbulent Free Shear Flows. 4 Units.
Practical and theoretical aspects of turbulent free shear flows. Instability, global scaling laws, mixing, and noise generation in incompressible and compressible shear layers, jets, and wakes. Kelvin-Helmholtz instability, near- and far-field growth rates, effect of compressibility, aeroacoustics of jets.

Prerequisite: ENGRMAE 200B and ENGRMAE 230A and ENGRMAE 230B. ENGRMAE 200B with a grade of B- or better. ENGRMAE 230A with a grade of B- or better. ENGRMAE 230B with a grade of B- or better

Restriction: Graduate students only.

ENGRMAE 235P. Engineering Design and Simulation: Tools and Process. 4 Units.
Practical techniques and use of industry tools that improve the engineering design process by simulating the performance of design options prior to the costly steps of prototyping and manufacturing are covered. Applicable to a wide variety of engineering disciplines.

Same as ENGR 235P.

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

ENGRMAE 236. Nonequilibrium Gas Dynamics. 4 Units.
Molecular description of fluid flow. Boltzmann equation. Chapman-Enskog expansion for flows with translational nonequilibrium. Shock structure. Inviscid flows with chemical and vibrational nonequilibrium. Not offered every year.

Prerequisite: ENGRMAE 230C. ENGRMAE 230C with a grade of B- or better

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. ENGRMAE 230C with a grade of B- or better

Restriction: Graduate students only.

ENGRMAE 239. Dynamics of Unsteady Flows. 4 Units.
Unsteady potential flow modeling (Kelvin's circulation theorem, unsteady Bernoulli's equation). Theodorsen's frequency response, Wagner's step response, and the Kussner sharp-edged gust. State Space approximations for Unsteady Loads. Vortex Lattice. Flutter.

Prerequisite: ENGRMAE 230A is recommended.

Restriction: Graduate students only.

ENGRMAE 240. Inertial Navigation. 4 Units.
Provides a basic understanding of 1) theory, operation, and performance characteristics of a strapdown inertial navigation system (INS), (2) distinction between strap down and gimbaled INS, (3) Kalman filtering theory and its application to strap down INS aiding.

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.
Spatial rigid-body transformations. Forward and inverse kinematics. Jacobian of serial and parallel chains. Screw coordinates and transformations. Rate and static analyses using screw theory. Singularity analysis. Trajectory generation. Not offered every year.

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 247P. 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.

Restriction: Master of Engineering students only. 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 249P. 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.

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

ENGRMAE 250. Biorobotics. 4 Units.
Sensors, actuators, and neural circuits for biological movement control from an engineering perspective. Current approaches to robotic and mechatronic devices that support and enhance human movement in health and following neurologic injuries like stroke and spinal cord injury.

Restriction: Graduate students only.

ENGRMAE 251. Micro/Nano Robotics. 4 Units.
Covers the emerging field of robotics at small scale (micro/nano robotics). Understanding different physical phenomena at small scales, the differences between nano and micro robotics, common fabrication, and different mechanisms of locomotion and environmental interaction.

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

Concurrent with ENGRMAE 173.

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 252P. 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.

Same as ENGR 252P.

Restriction: Graduate students only. Master of Engineering 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 254P. 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: Master of Engineering students only. 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 257. Materials Failure and Fracture. 4 Units.
Introduces materials failure and fracture behaviors under mechanical, thermal, and environmental conditions. It aims to provide a solid foundation and basic understanding of classic fatigue and fracture problems, and their underlying physical mechanisms.

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

ENGRMAE 257P. Fabrication and Characterization of Nanomaterials . 4 Units.
Introduction to nanoscale materials and experimental and computational techniques. Topics materials synthesis techniques, thin film deposition, nanoparticle and nanowire growth, characterization with electrons and X-rays, forces and surface interactions at the nanoscale, structure-property scaling laws, and atomistic/multiscale computer modeling.

Restriction: Master of Engineering students only. 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. ENGRMAE 254 with a grade of B- or better

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 259P. 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: Master of Engineering students only. Graduate students only.

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

Prerequisite: ENGRMAE 261 or CHEM 245 or EARTHSS 240. ENGRMAE 261 with a grade of B- or better. CHEM 245 with a grade of B- or better. EARTHSS 240 with a grade of B- or better

Same as CHEM 241.

Restriction: Graduate students only.

ENGRMAE 263. Aviation Systems and the Environment. 4 Units.
Methods for analyzing aviation systems, flight and engine performance, operations, and associated modern environmental challenges, including fuel burn, emissions, and noise are introduced. Analysis methods and technological and policy approaches for environmental impact mitigation examined.

Restriction: Graduate students only.

Concurrent with ENGRMAE 163.

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.
Advanced topics in linear systems: bases, linear operator representations, and Jordan forms. Review of dynamical systems, and stability. Time-varying systems, discrete-time representations, and multi-input/multi-output systems. Introduction to continuous and discrete time linear regulator (LQR) problems. Not offered every year.

Prerequisite: ENGRMAE 270A. ENGRMAE 270A with a grade of B- or better

Restriction: Graduate students only.

ENGRMAE 271. Network Control. 4 Units.
Provides foundations on graph-theoretic, probabilistic and analytic techniques that have proven instrumental for studying networked dynamical systems. Applications are presented in diverse areas of science and engineering that include the coordination of vehicles and distribution of energy and resources.

Restriction: Graduate students only.

ENGRMAE 272. Robust Control Theory. 4 Units.
Methods for control design of systems with uncertainty. Feedback stability and small gain theorem. Multivariable stability margins and multiplier theory. H-infinity-optimal control, linear matrix inequalities. Not offered every year.

Prerequisite: ENGRMAE 270A. ENGRMAE 270A with a grade of B- or better

Restriction: Graduate students only.

ENGRMAE 273. Stochastic Control. 4 Units.
Introduction to the tools stochastic differential equations and stochastic control. Focus on optimal control of dynamical systems in the presence of stochastic noise. Basic concepts are also central in various branches of theoretical physics and mathematical finance; examples are discussed.

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. ENGRMAE 200A with a grade of B- or better. ENGRMAE 270A with a grade of B- or better

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. ENGRMAE 270B with a grade of B- or better

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. ENGRMAE 200A with a grade of B- or better. ENGRMAE 270A with a grade of B- or better

Restriction: Graduate students only.

ENGRMAE 277. Learning Control Systems. 4 Units.
Supervised learning for classification and regression: perceptrons, support vector machines, feed-forward neural networks, Gaussian processes. Generalization and model selection: cross-validation, regularization, and Bayesian methods. Unsupervised learning: clustering and dimensionality reduction. Learning control systems. Introduction to reinforcement learning.

Restriction: Graduate students only.

ENGRMAE 278. Parameter and State Estimation. 4 Units.
Bayesian and frequentist approaches to parameter and state estimation. Properties of estimators. Linear Gaussian systems and the Kalman Filter. Nonlinear state estimation, extended and unscented Kalman Filters. Introduction to Monte Carlo methods and particle filtering. Application to tracking and navigation.

Prerequisite: ENGRMAE 200A and ENGRMAE 270A. ENGRMAE 200A with a grade of B- or better. ENGRMAE 270A with a grade of B- or better

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. ENGRMAE 270A with a grade of B- or better. ENGRMAE 241 with a grade of B- or better

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. Materials fee.

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 285. Engineering Design Under Uncertainty. 4 Units.
Introduces students to statistical and ML methods used in engineering design under uncertainty. Students learn how to probabilistically formulate a design problem, translate the formulations into a computer, and systematically find the solution.

Restriction: Graduate students only.

ENGRMAE 286. Design for Human Movement. 4 Units.
Introduces techniques for analysis and modeling of human locomotion, with a focus on lower-limb rehabilitating and robotic assistive devices. Discusses background and current research, with assignments covering independent reading, computer simulations, and a final project.

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

ENGRMAE 291. Research Communication in Engineering. 4 Units.
Guides students along research communication milestones by completion of a conference/journal publication, research proposal, MS thesis, or other significant publication. Peer review, response to reviewers, and a presentation are used to build skill and confidence.

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

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 295P. Special Topics in Mechanical and Aerospace Engineering. 4 Units.
Studies in selected areas of Mechanical and Aerospace Engineering. Topics addressed vary each quarter.

Repeatability: Unlimited as topics vary.

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

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