Electrical Engineering and Computer Sciences/Materials Science and Engineering Joint Major

Bachelor of Science (BS)

The joint major programs are designed for students who wish to undertake study in two areas of engineering in order to qualify for employment in either field or for positions in which competence in two fields is required. These curricula include the core courses in each of the major fields. While they require slightly increased course loads, they can be completed in four years. Both majors are shown on the student’s transcript of record.

For students interested in materials and devices, a joint major in Electrical Engineering and Computer Sciences (EECS)/Materials Science and Engineering (MSE) can be valuable. The program combines the study of materials from a broad perspective, as taught in MSE, with the study of their applications in electronic devices and circuits, as taught in EECS.

Admission to the Joint Major

Admission directly to a joint major is closed to freshmen and junior transfer applicants. Students interested in a joint program may apply Admission directly to a joint major is closed to freshmen and junior transfer applicants. Students interested in a joint program may apply directly to a joint major is closed to freshmen and junior transfer applicants. Students interested in a joint program may apply directly. Please see the College of Engineering joint majors website (http://engineering.berkeley.edu/academics/majors-minors/joint-majors/) for complete details.

In addition to the University, campus, and college requirements, students must fulfill the below requirements specific to their major program.

General Guidelines

1. All courses taken in satisfaction of major requirements must be taken for a letter grade.

2. No more than one upper division course may be used to simultaneously fulfill requirements for a student’s major and minor programs.

3. A minimum overall grade point average (GPA) of 2.0 is required for all work undertaken at UC Berkeley.

4. A minimum GPA of 2.0 is required for all technical courses taken in satisfaction of major requirements.

For information regarding residence requirements and unit requirements, please see the College Requirements tab.

For a detailed plan of study by year and semester, please see the Plan of Study tab.

Lower Division Requirements

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH 1A</td>
<td>Calculus</td>
<td>4</td>
</tr>
<tr>
<td>MATH 1B</td>
<td>Calculus</td>
<td>4</td>
</tr>
<tr>
<td>MATH 53</td>
<td>Multivariable Calculus</td>
<td>4</td>
</tr>
<tr>
<td>MATH 54</td>
<td>Linear Algebra and Differential Equations</td>
<td>4</td>
</tr>
</tbody>
</table>

Upper Division Requirements

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHEM 1A &amp; 1AL</td>
<td>General Chemistry and General Chemistry Laboratory</td>
<td>5</td>
</tr>
<tr>
<td>CHEM 4A</td>
<td>General Chemistry and Quantitative Analysis</td>
<td></td>
</tr>
<tr>
<td>PHYSICS 7A</td>
<td>Physics for Scientists and Engineers</td>
<td>12-13</td>
</tr>
<tr>
<td>PHYSICS 7B &amp; 7C</td>
<td>Physics for Scientists and Engineers</td>
<td></td>
</tr>
<tr>
<td>PHYSICS 5A &amp; Introductory Mechanics and Relativity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PHYSICS 5B &amp; Introductory Electromagnetism, Waves, and</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PHYSICS 5B &amp; Optics</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PHYSICS 5C &amp; Introduction to Experimental Physics I &amp;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PHYSICS 5C &amp; Introduction to Experimental Physics II &amp;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ENGIN 7</td>
<td>Introduction to Computer Programming for Scientists and Engineers</td>
<td>4</td>
</tr>
<tr>
<td>COMPSCI 61A</td>
<td>The Structure and Interpretation of Computer Programs</td>
<td></td>
</tr>
<tr>
<td>ENGIN 40</td>
<td>Engineering Thermodynamics</td>
<td>4</td>
</tr>
<tr>
<td>MAT SCI 45</td>
<td>Properties of Electronic Materials</td>
<td>3</td>
</tr>
<tr>
<td>MAT SCI 45L</td>
<td>Properties of Materials Laboratory</td>
<td>1</td>
</tr>
<tr>
<td>EECS 16A</td>
<td>Designing Information Devices and Systems I</td>
<td>4</td>
</tr>
<tr>
<td>COMPSCI 61B</td>
<td>Data Structures</td>
<td>4</td>
</tr>
<tr>
<td>COMPSCI 61C</td>
<td>Data Structures and Programming Methodology</td>
<td></td>
</tr>
<tr>
<td>EECS 151</td>
<td>Introduction to Digital Design and Integrated Circuits (must also take EECS 151LA or EECS 151LB)</td>
<td>4-5</td>
</tr>
<tr>
<td>EL ENG 105</td>
<td>Microelectronic Devices and Circuits</td>
<td>4</td>
</tr>
<tr>
<td>EL ENG 117</td>
<td>Electromagnetic Fields and Waves</td>
<td>4</td>
</tr>
<tr>
<td>EL ENG 130</td>
<td>Integrated-Circuit Devices</td>
<td>4</td>
</tr>
<tr>
<td>MAT SCI 102</td>
<td>Bonding, Crystallography, and Crystal Defects</td>
<td>3</td>
</tr>
<tr>
<td>MAT SCI 103</td>
<td>Phase Transformations and Kinetics</td>
<td>3</td>
</tr>
<tr>
<td>MAT SCI 104 &amp; 104L</td>
<td>Materials Characterization Laboratory</td>
<td></td>
</tr>
<tr>
<td>MAT SCI 131</td>
<td>Additive Manufacturing Processes and Systems for Advanced Materials</td>
<td>3</td>
</tr>
<tr>
<td>PHYSICS 137A</td>
<td>Quantum Mechanics</td>
<td>4</td>
</tr>
<tr>
<td>PHYSICS 141A</td>
<td>Solid State Physics</td>
<td>4</td>
</tr>
<tr>
<td>STAT 134</td>
<td>Concepts of Probability</td>
<td>4</td>
</tr>
<tr>
<td>EECS 141A</td>
<td>Probability and Random Processes</td>
<td></td>
</tr>
</tbody>
</table>

Upper division technical electives: two courses 6-8

Select at least 3 units from the MAT SCI 120 series
EECS Five-Year BS/MS

This program is geared toward students who would like to pursue an education beyond the BS/BA, allowing them to achieve greater breadth and depth of knowledge and do some research. It is not intended for students who have definitely decided to pursue a PhD immediately following graduation. Those students are advised to apply for a PhD program at Berkeley or elsewhere during their senior year. Students who have been accepted into the five-year BA/MS or BS/MS are free to change their minds later and apply to enter the PhD program or apply to a PhD program at another university. Their subsequent admission to the PhD program is competitive with our other PhD applicants.

The program is focused on interdisciplinary training at a graduate level; with at least 8 units of course work outside EECS required. Students will emerge as leaders in their technical and professional fields.

- Program is focused on interdisciplinary study and more experience in aligned technical fields such as physics, materials science, statistics, biology, etc., and/or professional disciplines such as management of technology, business law, and public policy.
- Participants, if admitted to the program, must begin the graduate portion in the semester immediately following the conferral of their bachelor's degree.
- Participation in the program is permitted for only one additional year (two semesters) beyond the bachelor's degree.
- Participation is only available to Berkeley EECS and CDSS Computer Science undergraduates.
- Participants in program are self-funded.
- Participants in program may serve as Graduate Student Instructors with the approval of their faculty research advisor and the 5th Year MS Committee.

For further information regarding this program, please see the Department's website (https://eecs.berkeley.edu/academics/graduate/industry-programs/5yrms/).

Materials Science and Engineering Five-Year BS/MS

The five-year combined Bachelor of Science/Master of Science program augments the existing four-year undergraduate program with a fifth year of graduate study that provides a professionally-oriented component, preparing students for careers in engineering or engineering management within the business, government, and/or industrial sectors. In this program, students earn a bachelor's degree and subsequently, a Master of Science degree under Plan II (without thesis) of the Academic Senate. This five-year program emphasizes interdisciplinary study through an independent project coupled to coursework. The program is open to undergraduate Materials Science and Engineering majors (both single or joint majors) only.

Unit Requirements (minimum 24 units)

- At least 12 units must be graduate units in major subject (200+ level)
- Individual study or research
  - At least 1 unit/semester (2 units total)
  - No more than 2 units/semester (4 units total)
- Remaining 12 units may be letter graded upper-division or graduate courses approve by major field advisor.
- A grade of B or better in three of five core course categories (thermodynamics, structure or phase transformations, characterization, processing and properties) at the 200+ level
- Minimum 3.0 GPA must be maintained
- Each course may only satisfy one category
- An independent project will be performed as part of a required two course sequence, MSE 296A&B, under the supervision of a faculty member. Students are encouraged to identify faculty supervisors as soon as possible, but by no later than the beginning of the ninth semester. Students will be required to complete both a project report and an oral presentation.

For further information regarding this program, please see the program's website (https://mse.berkeley.edu/five-year-bs-ms/).

Students in the College of Engineering must complete no fewer than 120 semester units with the following provisions:

1. Completion of the requirements of one engineering major program (https://engineering.berkeley.edu/students/undergraduate-guide/degree-requirements/major-programs/) of study.
2. A minimum overall grade point average of 2.00 (C average) and a minimum 2.00 grade point average in upper division technical coursework required of the major.
3. The final 30 units and two semesters must be completed in residence in the College of Engineering on the Berkeley campus.
4. All technical courses (math, science, and engineering) that can fulfill requirements for the student's major must be taken on a letter graded basis (unless they are only offered P/NP).
5. Entering freshmen are allowed a maximum of eight semesters to complete their degree requirements. Entering junior transfers are allowed five semesters to complete their degree requirements. Summer terms are optional and do not count toward the maximum. Students are responsible for planning and satisfactorily completing all graduation requirements within the maximum allowable semesters.
6. Adhere to all college policies and procedures (https://engineering.berkeley.edu/students/undergraduate-guide/policies-procedures/) as they complete degree requirements.
7. Complete lower division technical courses before enrolling in upper division technical courses.

Humanities and Social Sciences (H/SS) Requirement

To promote a rich and varied educational experience outside of the technical requirements for each major, the College of Engineering has a six-course Humanities and Social Sciences breadth requirement (http://engineering.berkeley.edu/student-services/degree-requirements/humanities-and-social-sciences/), which must be completed to graduate. This requirement, built into all the engineering programs of study, includes two Reading and Composition courses (R&C), and four additional courses within which a number of specific conditions must be satisfied. See the humanities and social sciences (https://
At least 120 semester units of courses subject to certain guidelines:

Class Schedule Requirements

- Minimum units per semester: 12.0
- Maximum units per semester: 20.5
- Minimum technical courses: College of Engineering undergraduates must include at least two letter graded technical courses (of at least 3 units each) in their semester program. Every semester students are expected to make normal progress in their declared major. Normal progress is determined by the student’s Engineering Student Services Advisor. (Note: For most majors, normal progress ([https://engineering.berkeley.edu/academics/undergraduate-guide/policies-procedures/scholarship-progress/#ac12282](https://engineering.berkeley.edu/academics/undergraduate-guide/policies-procedures/scholarship-progress/#ac12282)) each semester toward their declared major. Students who are not in compliance with this policy by the end of the fifth week of the semester are subject to a registration block that will delay enrollment for the following semester.
- All technical courses (math, science, engineering) that satisfy requirements for the major must be taken on a letter-graded basis (unless only offered as P/NP).

Minimum Academic Requirements

- Students must have a minimum overall and semester grade point average of 2.00 (C average). Students will be subject to suspension or dismissal from the University if during any fall or spring semester their overall UC GPA falls below a 2.00, or their semester GPA is less than 2.00.
- Students must achieve a minimum grade point average of 2.00 (C average) in upper division technical courses required for the major curriculum each semester.
- A minimum overall grade point average of 2.00 and a minimum 2.00 grade point average in upper division technical course work required for the major are required to earn a Bachelor of Science in the College of Engineering.
- Students must make normal degree progress toward the Bachelor of Science degree and their officially declared major.

Unit Requirements

To earn a Bachelor of Science in Engineering, students must complete at least 120 semester units of courses subject to certain guidelines:

- Completion of the requirements of one engineering major ([https://engineering.berkeley.edu/students/undergraduate-guide/degree-requirements/major-programs/](https://engineering.berkeley.edu/students/undergraduate-guide/degree-requirements/major-programs/)) of study.
- A maximum of 16 units of special studies coursework (courses numbered 97, 98, 99, 197, 198, or 199) is allowed to count towards the B.S. degree, and no more than 4 units in any single term can be counted.
- A maximum of 4 units of physical education from any school attended will count towards the 120 units.
- Passed (P) grades may account for no more than one third of the total units completed at UC Berkeley, Fall Program for First Semester (FPF), UC Education Abroad Program (UCEAP), or UC Berkeley Washington Program (UCDC) toward the 120 overall minimum unit requirement. Transfer credit is not factored into the limit. This includes transfer units from outside of the UC system, other UC campuses, credit-bearing exams, as well as UC Berkeley Extension XB units.

Normal Progress

Students in the College of Engineering must enroll in a full-time program and make normal progress ([https://engineering.berkeley.edu/students/undergraduate-guide/policies-procedures/scholarship-progress/#ac12282](https://engineering.berkeley.edu/students/undergraduate-guide/policies-procedures/scholarship-progress/#ac12282)) each semester toward their declared major. Students who fail to achieve normal academic progress shall be subject to suspension or dismissal. (Note: Students with official accommodations established by the Disabled Students' Program, with health or family issues, or with other reasons deemed appropriate by the dean may petition for an exception to normal progress rules.)

University of California Requirements

Entry Level Writing ([https://guide.berkeley.edu/undergraduate/education/#earningyourdegreetext](https://guide.berkeley.edu/undergraduate/education/#earningyourdegreetext))

All students who will enter the University of California as freshmen must demonstrate their command of the English language by satisfying the Entry Level Writing Requirement (ELWR). The UC Entry Level Writing Requirement website ([https://admission.universityofcalifornia.edu/elwr/](https://admission.universityofcalifornia.edu/elwr/)) provides information on how to satisfy the requirement.

American History and American Institutions ([https://guide.berkeley.edu/undergraduate/education/#earningyourdegreetext](https://guide.berkeley.edu/undergraduate/education/#earningyourdegreetext))

The American History and American Institutions (AH&I) requirements are based on the principle that a U.S. resident graduated from an American university should have an understanding of the history and governmental institutions of the United States.

Campus Requirement

American Cultures ([https://guide.berkeley.edu/undergraduate/education/#earningyourdegreetext](https://guide.berkeley.edu/undergraduate/education/#earningyourdegreetext))

The American Cultures requirement is a Berkeley campus requirement, one that all undergraduate students at Berkeley need to pass in order to graduate. You satisfy the requirement by passing, with a grade not lower than C- or P, an American Cultures course. You may take an American Cultures course any time during your undergraduate career at Berkeley. The requirement was instituted in 1991 to introduce students to the diverse cultures of the United States through a comparative framework. Courses are offered in more than fifty departments in many different disciplines at both the lower and upper division level.

For more detailed information regarding the courses listed below (e.g., elective information, GPA requirements, etc.), please see the College Requirements and Major Requirements tabs.

<table>
<thead>
<tr>
<th>Course</th>
<th>Fall Units</th>
<th>Spring Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHEM 1A &amp; CHEM 1AL, or CHEM 4A</td>
<td>5 MATH 1B</td>
<td>4</td>
</tr>
<tr>
<td>MATH 1A</td>
<td>4 PHYSICS 7A</td>
<td>3-4</td>
</tr>
<tr>
<td>or 5A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Humanities/Social Sciences course</td>
<td>3-4 ENGIN 7 or COMPSCI 61A</td>
<td>4</td>
</tr>
<tr>
<td>Reading &amp; Composition Part A Course</td>
<td>4 Reading &amp; Composition Part B Course</td>
<td>4</td>
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Table: Normal Progress

<table>
<thead>
<tr>
<th>Units</th>
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<th>15-16</th>
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</thead>
<tbody>
<tr>
<td>3-4</td>
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<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
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</table>
Technical electives must include two courses:

<table>
<thead>
<tr>
<th>Course</th>
<th>Fall Units</th>
<th>Spring Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>COMPSCI 61B or 61BL</td>
<td>4</td>
<td>EEC 16A</td>
</tr>
<tr>
<td>MAT SCI 102</td>
<td>3</td>
<td>MAT SCI 103</td>
</tr>
<tr>
<td>PHYSICS 137A</td>
<td>4</td>
<td>MAT SCI 104</td>
</tr>
<tr>
<td>EL ENG 117</td>
<td>4</td>
<td>EL ENG 111</td>
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<tr>
<td>EL ENG 140 or 151</td>
<td>4</td>
<td>MAT SCI 111</td>
</tr>
<tr>
<td>MAT SCI 131</td>
<td>3</td>
<td>EL ENG 130</td>
</tr>
<tr>
<td>PHYSICS 141A</td>
<td>4</td>
<td>EL SCI 104</td>
</tr>
<tr>
<td>Humanities/Social Sciences course²</td>
<td>3-4</td>
<td></td>
</tr>
</tbody>
</table>

**Total Units: 122-133**

4 The Humanities/Social Sciences (H/SS) requirement includes two approved Reading & Composition (R&C) courses and four additional approved courses, which are a number of specific conditions must be satisfied. R&C courses must be taken for a letter grade (C- or better required). The first half (R&C Part A) must be completed by the end of the freshman year; the second half (R&C Part B) must be completed by no later than the end of the sophomore year. The remaining courses may be taken at any time during the program. See engineering.berkeley.edu/hss (https://engineering.berkeley.edu/academics/undergraduate-guide/degree-requirements/humanities-and-social-sciences/) for complete details and a list of approved courses.

5 MAT SCI 45/MAT SCI 45L can be taken in either the Fall or Spring semesters. Both offerings deliver the same fundamental content. The Fall offering draws more examples from hard materials (e.g. semiconductors, metals, and ceramics), whereas the Spring offering will draw more examples from soft materials (e.g. polymers and biomaterials).

6 CHEM 4A is intended for students majoring in chemistry or a closely related field.

## Electrical Engineering and Computer Sciences

### MISSION

1. Preparing graduates to pursue postgraduate education in electrical engineering, computer science, or related fields.
2. Preparing graduates for success in technical careers related to electrical and computer engineering, or computer science and engineering.
3. Preparing graduates to become leaders in fields related to electrical and computer engineering or computer science and engineering.

### LEARNING GOALS

1. An ability to apply knowledge of mathematics, science, and engineering.
2. An ability to configure, apply test conditions, and evaluate outcomes of experimental systems.
3. An ability to design systems, components, or processes that conform to given specifications and cost constraints.
4. An ability to work cooperatively, respectfully, creatively, and responsibly as a member of a team.
5. An ability to identify, formulate, and solve engineering problems.
6. An understanding of the norms of expected behavior in engineering practice and their underlying ethical foundations.
7. An ability to communicate effectively by oral, written, and graphical means.
8. An awareness of global and societal concerns and their importance in developing engineering solutions.
9. An ability to independently acquire and apply required information, and an appreciation of the associated process of life-long learning.
10. A knowledge of contemporary issues.
11. An in-depth ability to use a combination of software, instrumentation, and experimental techniques practiced in circuits, physical electronics, communication, networks and systems, hardware, programming, and computer science theory.
Materials Science

Measured Curricular Outcomes

The program is designed around a set of curricular outcomes.

1. Be able to apply general math, science and engineering skills to the solution of engineering problems.
2. Be aware of the social, safety and environmental consequences of their work, and be able to engage in public debate regarding these issues.
3. Be able to apply core concepts in materials science to solve engineering problems.
4. Be knowledgeable of contemporary issues relevant to materials science and engineering.
5. Be able to select materials for design and construction.
6. Understand the importance of life-long learning.
7. Be able to design and conduct experiments, and to analyze data.
8. Understand the professional and ethical responsibilities of a materials scientist and engineer.
9. Be able to work both independently and as part of a team.
10. Be able to communicate effectively while speaking, employing graphics, and writing.
11. Possess the skills and techniques necessary for modern materials engineering practice.

Educational Objectives for Graduates

Stated succinctly, graduates from the program will have the following skills:

1. Know the fundamental science and engineering principles relevant to materials.
2. Understand the relationship between nano/microstructure, characterization, properties and processing, and design of materials.
3. Have the experimental and computational skills for a professional career or graduate study in materials.
4. Possess a knowledge of the significance of research, the value of continued learning, and environmental/social issues surrounding materials.
5. Be able to communicate effectively, to work in teams and to assume positions as leaders.

• Electrical Engineering and Computer Sciences (p. 5)
• Materials Science and Engineering (p. 18)

Electrical Engineering Courses

Expand all course descriptions [+]Collapse all course descriptions [-]
EL ENG 39 Freshman/Sophomore Seminar 2 - 4 Units
Terms offered: Spring 2023, Fall 2022, Spring 2022
Freshman and sophomore seminars offer lower division students the opportunity to explore an intellectual topic with a faculty member and a group of peers in a small-seminar setting. These seminars are offered in all campus departments; topics vary from department to department and from semester to semester. Enrollment limits are set by the faculty, but the suggested limit is 25.
Freshman/Sophomore Seminar: Read More [+]

Rules & Requirements

Prerequisites: Priority given to freshmen and sophomores

Repeat rules: Course may be repeated for credit when topic changes.

Hours & Format

Fall and/or spring: 15 weeks - 2-4 hours of seminar per week

Additional Details

Subject/Course Level: Electrical Engineering/Undergraduate

Grading/Final exam status: The grading option will be decided by the instructor when the class is offered. Final exam required.

Freshman/Sophomore Seminar: Read Less [-]

EL ENG 42 Introduction to Digital Electronics 3 Units
Terms offered: Fall 2013, Summer 2013 8 Week Session, Spring 2013
This course serves as an introduction to the principles of electrical engineering, starting from the basic concepts of voltage and current and circuit elements of resistors, capacitors, and inductors. Circuit analysis is taught using Kirchhoff's voltage and current laws with Thevenin and Norton equivalents. Operational amplifiers with feedback are introduced as basic building blocks for amplification and filtering. Semiconductor devices including diodes and MOSFETS and their IV characteristics are covered. Applications of diodes for rectification, and design of MOSFETS in common source amplifiers are taught. Digital logic gates and design using CMOS as well as simple flip-flops are introduced. Speed and scaling issues for CMOS are considered. The course includes as motivating examples designs of high level applications including logic circuits, amplifiers, power supplies, and communication links.
Introduction to Digital Electronics: Read More [+]

Rules & Requirements

Prerequisites: Mathematics 1B

Credit Restrictions: Students will receive no credit for 42 after taking 40 or 100.

Hours & Format

Fall and/or spring: 15 weeks - 3 hours of lecture and 1 hour of discussion per week

Summer: 8 weeks - 6 hours of lecture and 2 hours of discussion per week

Additional Details

Subject/Course Level: Electrical Engineering/Undergraduate

Grading/Final exam status: Letter grade. Final exam required.

Introduction to Digital Electronics: Read Less [-]
EL ENG 49 Electronics for the Internet of Things 4 Units
Terms offered: Spring 2020, Spring 2019, Fall 2018
Electronics has become pervasive in our lives as a powerful technology with applications in a wide range of fields including healthcare, environmental monitoring, robotics, or entertainment. This course teaches how to build electronic circuits that interact with the environment through sensors and actuators and how to communicate wirelessly with the internet to cooperate with other devices and with humans. In the laboratory students design and build representative samples such as solar harvesters, robots, that exchange information with or are controlled from the cloud.
Electronics for the Internet of Things: Read More [+]

Objectives & Outcomes

Course Objectives: Electronics has become a powerful and ubiquitous technology supporting solutions to a wide range of applications in fields ranging from science, engineering, healthcare, environmental monitoring, transportation, to entertainment. The objective of this course is to teach students majoring in these and related subjects how to use electronic devices to solve problems in their areas of expertise.

Through the lecture and laboratory, students gain insight into the possibilities and limitations of the technology and how to use electronics to help solve problems. Students learn to use electronics to interact with the environment through sound, light, temperature, motion using sensors and actuators, and how to use electronic computation to orchestrate the interactions and exchange information wirelessly over the internet.

Student Learning Outcomes: Deploy electronic sensors and interface them to microcontrollers through digital and analog channels as well as common protocols (I2C, SPI).

- Design, build and test electronic devices leveraging these concepts.
- Interact with the internet and cloud services using protocols such as http, MQTT, Blynk.
- Interface DC motors, steppers and servos to microcontrollers.
- Represent information with voltage, current, power, and energy and how to measure these quantities with laboratory equipment.
- To use and program low-cost and low-power microcontrollers for sensing, actuation, and information processing, and find and use program libraries supporting these tasks.
- Understand and make basic low-pass and high-pass filters, Wheatstone bridge etc.
- Use electronics to sense and actuate physical parameters such as temperature, humidity, sound, light, and motion.

Rules & Requirements

Prerequisites: ENGIN 7, COMPSCI 10, or equivalent background in computer programming (including COMPSCI 61A or COMPSCI C8 / INFO C8 / STAT C8); MATH 1A or equivalent background in Calculus.

Hours & Format

Fall and/or spring: 15 weeks - 3 hours of lecture, 2 hours of discussion, and 3 hours of laboratory per week

Additional Details

Subject/Course Level: Electrical Engineering/Undergraduate

Grading/Final exam status: Letter grade. Final exam required.

Instructor: Boser

Electronics for the Internet of Things: Read Less [-]

EL ENG 84 Sophomore Seminar 1 or 2 Units
Terms offered: Fall 2022, Spring 2022, Fall 2021
Sophomore seminars are small interactive courses offered by faculty members in departments all across the campus. Sophomore seminars offer opportunity for close, regular intellectual contact between faculty members and students in the crucial second year. The topics vary from department to department and semester to semester. Enrollment limited to 15 sophomores.

Sophomore Seminar: Read More [+]

Rules & Requirements

Prerequisites: At discretion of instructor

Repeat rules: Course may be repeated for credit when topic changes.

Hours & Format

Fall and/or spring:
5 weeks - 3-6 hours of seminar per week
10 weeks - 1.5-3 hours of seminar per week
15 weeks - 1-2 hours of seminar per week

Summer:
6 weeks - 2.5-5 hours of seminar per week
8 weeks - 1.5-3.5 hours of seminar per week

Additional Details

Subject/Course Level: Electrical Engineering/Undergraduate

Grading/Final exam status: The grading option will be decided by the instructor when the class is offered. Final exam required.

Sophomore Seminar: Read Less [-]

EL ENG 97 Field Study 1 - 4 Units
Terms offered: Fall 2016, Fall 2015, Spring 2015
Students take part in organized individual field sponsored programs with off-campus companies or tutoring/mentoring relevant to specific aspects and applications of computer science on or off campus. Note Summer CPT or OPT students: written report required. Course does not count toward major requirements, but will be counted in the cumulative units toward graduation.

Field Study: Read More [+]

Rules & Requirements

Prerequisites: Consent of instructor (see department adviser)

Repeat rules: Course may be repeated for credit without restriction.

Hours & Format

Fall and/or spring: 15 weeks - 1-4 hours of fieldwork per week

Summer:
6 weeks - 2.5-10 hours of fieldwork per week
8 weeks - 2-7.5 hours of fieldwork per week

Additional Details

Subject/Course Level: Electrical Engineering/Undergraduate

Grading/Final exam status: Offered for pass/not pass grade only. Final exam not required.

Field Study: Read Less [-]
EL ENG 98 Directed Group Study for Undergraduates 1 - 4 Units
Terms offered: Fall 2021, Fall 2020, Fall 2016
Group study of selected topics in electrical engineering, usually relating to new developments.
Directed Group Study for Undergraduates: Read More [+]

Rules & Requirements
Repeat rules: Course may be repeated for credit without restriction.

Hours & Format
Fall and/or spring: 15 weeks - 1-4 hours of directed group study per week

Additional Details
Subject/Course Level: Electrical Engineering/Undergraduate
Grading/Final exam status: Offered for pass/not pass grade only. Final exam not required.
Directed Group Study for Undergraduates: Read Less [-]

EL ENG 99 Individual Study and Research for Undergraduates 1 - 4 Units
Terms offered: Spring 2016, Fall 2015, Spring 2015
Supervised independent study and research for students with fewer than 60 units completed.
Individual Study and Research for Undergraduates: Read More [+]

Rules & Requirements
Prerequisites: Freshman or sophomore standing and consent of instructor. Minimum GPA of 3.4 required
Credit Restrictions: Enrollment is restricted; see the Introduction to Courses and Curricula section of this catalog.
Repeat rules: Course may be repeated for credit without restriction.

Hours & Format
Fall and/or spring: 15 weeks - 1-4 hours of independent study per week
Summer:
6 weeks - 1-5 hours of independent study per week
8 weeks - 1-4 hours of independent study per week

Additional Details
Subject/Course Level: Electrical Engineering/Undergraduate
Grading/Final exam status: Offered for pass/not pass grade only. Final exam not required.
Individual Study and Research for Undergraduates: Read Less [-]

EL ENG 105 Microelectronic Devices and Circuits 4 Units
Terms offered: Fall 2024, Spring 2024, Fall 2023
This course covers the fundamental circuit and device concepts needed to understand analog integrated circuits. After an overview of the basic properties of semiconductors, the p-n junction and MOS capacitors are described and the MOSFET is modeled as a large-signal device. Two port small-signal amplifiers and their realization using single stage and multistage CMOS building blocks are discussed. Sinusoidal steady-state signals are introduced and the techniques of phasor analysis are developed, including impedance and the magnitude and phase response of linear circuits. The frequency responses of single and multi-stage amplifiers are analyzed. Differential amplifiers are introduced.
Microelectronic Devices and Circuits: Read More [+]

Rules & Requirements
Prerequisites: EECS 16A and EECS 16B
Credit Restrictions: Students will receive no credit for EL ENG 105 after completing EL ENG 240A, or EL ENG 140.

Hours & Format
Fall and/or spring: 15 weeks - 3 hours of lecture, 1 hour of discussion, and 3 hours of laboratory per week

Additional Details
Subject/Course Level: Electrical Engineering/Undergraduate
Grading/Final exam status: Letter grade. Final exam required.
Microelectronic Devices and Circuits: Read Less [-]
EL ENG C106A Introduction to Robotics 4 Units
Terms offered: Fall 2017, Fall 2016, Fall 2015
An introduction to the kinematics, dynamics, and control of robot manipulators, robotic vision, and sensing. The course covers forward and inverse kinematics of serial chain manipulators, the manipulator Jacobian, force relations, dynamics, and control. It presents elementary principles on proximity, tactile, and force sensing, vision sensors, camera calibration, stereo construction, and motion detection. The course concludes with current applications of robotics in active perception, medical robotics, and other areas.
Introduction to Robotics: Read More [+]

Rules & Requirements
Prerequisites: EL ENG 120 or consent of instructor

Hours & Format
Fall and/or spring: 15 weeks - 3 hours of lecture, 1 hour of discussion, and 3 hours of laboratory per week

Additional Details
Subject/Course Level: Electrical Engineering/Undergraduate
Grading/Final exam status: Letter grade. Final exam required.
Instructor: Bajcsy
Formerly known as: Electrical Engineering C125/Bioengineering C125
Also listed as: BIO ENG C125
Introduction to Robotics: Read Less [-]

EL ENG C106B Robotic Manipulation and Interaction 4 Units
Terms offered: Spring 2017, Spring 2016
This course is a sequel to Electrical Engineering C106A/Bioengineering C125, which covers kinematics, dynamics and control of a single robot. This course will cover dynamics and control of groups of robotic manipulators coordinating with each other and interacting with the environment. Concepts will include an introduction to grasping and the constrained manipulation, contacts and force control for interaction with the environment. We will also cover active perception guided manipulation, as well as the manipulation of non-rigid objects. Throughout, we will emphasize design and human-robot interactions, and applications to applications in manufacturing, service robotics, tele-surgery, and locomotion.
Robotic Manipulation and Interaction: Read More [+]

Rules & Requirements
Prerequisites: EECS C106A / BIO ENG C125 or consent of the instructor

Hours & Format
Fall and/or spring: 15 weeks - 3 hours of lecture, 1 hour of discussion, and 3 hours of laboratory per week

Additional Details
Subject/Course Level: Electrical Engineering/Undergraduate
Grading/Final exam status: Letter grade. Alternative to final exam.
Instructors: Bajcsy, Sastry
Also listed as: BIO ENG C125B
Robotic Manipulation and Interaction: Read Less [-]
**EL ENG 108 Introduction to Electric Power and Renewable Energy 4 Units**

Terms offered: Spring 2024

This course is designed to provide an introduction to electric power conversion, distribution, and generation with renewable energy sources. The course will introduce fundamental concepts in the area of electric power, such as complex and reactive power, phasors, impedance, magnetic circuits and transformers, power factor, power quality, three-phase power, ac-dc conversion, and a conceptual overview of renewable energy and the integration of sustainable energy sources on the electric grid. Real world applications, ranging from ground-fault circuit interrupters to residential power distribution and solar photovoltaic dc-ac inverters will be explored in live lecture demonstration.

**Introduction to Electric Power and Renewable Energy:** Read More [+]

**Rules & Requirements**

**Prerequisites:** Differential equations and linear algebra (Math 54 or equivalent), Electricity and magnetism (Physics 7B or equivalent). Introduction to electric circuits (EE 16AB or equivalent). Students should enter the course with a basic working knowledge of RLC circuits.

**Hours & Format**

Fall and/or spring: 15 weeks - 3 hours of lecture and 1 hour of discussion per week.

**Additional Details**

**Subject/Course Level:** Electrical Engineering/Undergraduate

**Grading/Final exam status:** Letter grade. Final exam required.

**Instructor:** Pilawa

**Introduction to Electric Power and Renewable Energy:** Read Less [-]

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**EL ENG 113 Power Electronics 4 Units**

Terms offered: Fall 2024, Fall 2023, Fall 2022

Power conversion circuits and techniques. Characterization and design of magnetic devices including transformers, reactors, and electromagnetic machinery. Characteristics of bipolar and MOS power semiconductor devices. Applications to motor control, switching power supplies, lighting, power systems, and other areas as appropriate.

**Power Electronics:** Read More [+]

**Rules & Requirements**

**Prerequisites:** EL ENG 105 or background in circuit analysis (KVL, KCL, voltage/current relationships, etc.)

**Hours & Format**

Fall and/or spring: 15 weeks - 3 hours of lecture and 3 hours of laboratory per week.

**Additional Details**

**Subject/Course Level:** Electrical Engineering/Undergraduate

**Grading/Final exam status:** Letter grade. Final exam required.

**Instructors:** Pilawa, Boles

**Power Electronics:** Read Less [-]

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**EL ENG 113B Power Electronics Design 4 Units**

Terms offered: Spring 2024

This course is the second in a two-semester series to equip students with the skills needed to analyze, design, and prototype power electronic converters. While EE 113/213A provides an overview of power electronics fundamentals and applications, EE 113B/213B focuses on the practical design and hardware implementation of power converters. The primary focus of EE 113B/213B is time in the laboratory, with sequential modules on topics such as power electronic components, PCB layout, closed-loop control, and experimental validation. At the end of the course, students will have designed, prototyped, and validated a power converter from scratch, demonstrating a skill set that is critical for power electronics engineers in research and industry.

**Power Electronics Design:** Read More [+]

**Rules & Requirements**

**Repeat rules:** Course may be repeated for credit with instructor consent.

**Hours & Format**

Fall and/or spring: 15 weeks - 1.5 hours of lecture and 6 hours of laboratory per week.

**Additional Details**

**Subject/Course Level:** Electrical Engineering/Undergraduate

**Grading/Final exam status:** Letter grade. Alternate method of final assessment during regularly scheduled final exam group (e.g., presentation, final project, etc.).

**Instructor:** Boles

**Power Electronics Design:** Read Less [-]
EL ENG 117 Electromagnetic Fields and Waves 4 Units
Terms offered: Spring 2024, Spring 2023, Spring 2022
Review of static electric and magnetic fields and applications; Maxwell's equations; transmission lines; propagation and reflection of plane waves; introduction to guided waves, microwave networks, and radiation and antennas. Minilabs on statics, transmission lines, and waves. Explanation of cellphone antennas, WiFi communication, and other wireless technologies.

Electromagnetic Fields and Waves: Read More [+]

Rules & Requirements

Prerequisites: EECS 16B, MATH 53, and MATH 54; PHYSICS 7B or equivalent that covers AC circuits and electromagnetics up to Maxwell's equations

Hours & Format

Fall and/or spring: 15 weeks - 3 hours of lecture, 1 hour of discussion, and 2 hours of laboratory per week

Additional Details

Subject/Course Level: Electrical Engineering/Undergraduate
Grading/Final exam status: Letter grade. Final exam required.
Instructor: Yablonovitch

Electromagnetic Fields and Waves: Read Less [-]

EL ENG 118 Introduction to Optical Engineering 4 Units
Terms offered: Fall 2024, Fall 2023, Fall 2022

Introduction to Optical Engineering: Read More [+]

Rules & Requirements

Prerequisites: MATH 53; EECS 16A and EECS 16B, or MATH 54

Credit Restrictions: Students will receive no credit for Electrical Engineering 118 after taking Electrical Engineering 218A. A deficient grade in Electrical Engineering 119 may be removed by taking Electrical Engineering 118.

Hours & Format

Fall and/or spring: 15 weeks - 3 hours of lecture and 1 hour of discussion per week

Additional Details

Subject/Course Level: Electrical Engineering/Undergraduate
Grading/Final exam status: Letter grade. Final exam required.
Instructors: Waller, Kante

Introduction to Optical Engineering: Read Less [-]

EL ENG 120 Signals and Systems 4 Units
Terms offered: Fall 2024, Spring 2024, Fall 2023
Signals and Systems: Read More [+]

Rules & Requirements

Prerequisites: EECS 16A and EECS 16B

Hours & Format

Fall and/or spring: 15 weeks - 4 hours of lecture and 1 hour of recitation per week

Additional Details

Subject/Course Level: Electrical Engineering/Undergraduate
Grading/Final exam status: Letter grade. Final exam required.

Signals and Systems: Read Less [-]

EL ENG 121 Introduction to Digital Communication Systems 4 Units
Terms offered: Spring 2016, Fall 2014, Fall 2013
Introduction to the basic principles of the design and analysis of modern digital communication systems. Topics include source coding, channel coding, baseband and passband modulation techniques, receiver design, and channel equalization. Applications to design of digital telephone modems, compact disks, and digital wireless communication systems. Concepts illustrated by a sequence of MATLAB exercises.

Introduction to Digital Communication Systems: Read More [+]

Rules & Requirements

Prerequisites: EECS 16A, EECS 16B, and COMPSCI 70

Hours & Format

Fall and/or spring: 15 weeks - 3 hours of lecture and 1 hour of discussion per week

Additional Details

Subject/Course Level: Electrical Engineering/Undergraduate
Grading/Final exam status: Letter grade. Final exam required.

Introduction to Digital Communication Systems: Read Less [-]
EL ENG 122 Introduction to Communication Networks 4 Units
Terms offered: Spring 2024, Spring 2023, Spring 2022
This course focuses on the fundamentals of the wired and wireless communication networks. The course covers both the architectural principles for making these networks scalable and robust, as well as the key techniques essential for analyzing and designing them. The topics include graph theory, Markov chains, queuing, optimization techniques, the physical and link layers, switching, transport, cellular networks and Wi-Fi.
Introduction to Communication Networks: Read More [+]

Rules & Requirements
Prerequisites: COMPSCI 70

Hours & Format
Fall and/or spring: 15 weeks - 3 hours of lecture and 1 hour of discussion per week

Additional Details
Subject/Course Level: Electrical Engineering/Undergraduate
Grading/Final exam status: Letter grade. Final exam required.

EL ENG 123 Digital Signal Processing 4 Units
Terms offered: Spring 2024, Spring 2023, Spring 2022
Digital Signal Processing: Read More [+]

Rules & Requirements
Prerequisites: EL ENG 120

Hours & Format
Fall and/or spring: 15 weeks - 3 hours of lecture, 1 hour of discussion, and 1 hour of laboratory per week

Additional Details
Subject/Course Level: Electrical Engineering/Undergraduate
Grading/Final exam status: Letter grade. Final exam required.

EL ENG 126 Probability and Random Processes 4 Units
Terms offered: Spring 2017, Fall 2016, Spring 2016
Probability and Random Processes: Read More [+]

Rules & Requirements
Prerequisites: EECS 16A and EECS 16B

Hours & Format
Fall and/or spring: 15 weeks - 3 hours of lecture and 1 hour of discussion per week

Additional Details
Subject/Course Level: Electrical Engineering/Undergraduate
Grading/Final exam status: Letter grade. Final exam required.

EL ENG C128 Feedback Control Systems 4 Units
Terms offered: Spring 2024, Spring 2023, Spring 2022
Analysis and synthesis of linear feedback control systems in transform and time domains. Control system design by root locus, frequency response, and state space methods. Applications to electro-mechanical and mechatronics systems.
Feedback Control Systems: Read More [+]

Rules & Requirements
Prerequisites: EECS 16A or MEC ENG 100; MEC ENG 132 or EL ENG 120

Hours & Format
Fall and/or spring: 15 weeks - 3 hours of lecture, 1 hour of discussion, and 3 hours of laboratory per week

Additional Details
Subject/Course Level: Electrical Engineering/Undergraduate
Grading/Final exam status: Letter grade. Final exam required.
Also listed as: MEC ENG C134
Feedback Control Systems: Read Less [-]
**EL ENG 130 Integrated-Circuit Devices 4 Units**

Terms offered: Fall 2024, Spring 2024, Fall 2023

Overview of electronic properties of semiconductor. Metal-semiconductor contacts, pn junctions, bipolar transistors, and MOS field-effect transistors. Properties that are significant to device operation for integrated circuits. Silicon device fabrication technology.

Prerequisites: EECS 16A and EECS 16B

Credit Restrictions: Students will receive no credit for El Eng 130 after taking El Eng 230A.

**Hours & Format**

Fall and/or spring: 15 weeks - 3 hours of lecture and 1 hour of discussion per week

**Additional Details**

Subject/Course Level: Electrical Engineering/Undergraduate

Grading/Final exam status: Letter grade. Final exam required.

**Rules & Requirements**

Integrated-Circuit Devices: Read More [+]

**EL ENG 134 Fundamentals of Photovoltaic Devices 4 Units**

Terms offered: Spring 2024, Spring 2023, Spring 2022

This course is designed to give an introduction to, and overview of, the fundamentals of photovoltaic devices. Students will learn how solar cells work, understand the concepts and models of solar cell device physics, and formulate and solve relevant physical problems related to photovoltaic devices. Monocrystalline, thin film and third generation solar cells will be discussed and analyzed. Light management and economic considerations in a solar cell system will also be covered.

Prerequisites: EECS 16A and EECS 16B; or Math 54 and Physics 7B; or equivalent

**Hours & Format**

Fall and/or spring: 15 weeks - 3 hours of lecture and 1 hour of discussion per week

**Additional Details**

Subject/Course Level: Electrical Engineering/Undergraduate

Grading/Final exam status: Letter grade. Final exam required.

Instructor: Arias

Fundamentals of Photovoltaic Devices: Read Less [-]

**EL ENG 137A Introduction to Electric Power Systems 4 Units**

Terms offered: Fall 2024, Fall 2023, Fall 2022

Overview of conventional electric power conversion and delivery, emphasizing a systemic understanding of the electric grid with primary focus at the transmission level, aimed toward recognizing needs and opportunities for technological innovation. Topics include aspects of a.c. system design, electric generators, components of transmission and distribution systems, power flow analysis, system planning and operation, performance measures, and limitations of legacy technologies.

Prerequisites: Physics 7B; EECS 16A and EECS 16B, or consent of instructor

**Hours & Format**

Fall and/or spring: 15 weeks - 3 hours of lecture and 1 hour of discussion per week

**Additional Details**

Subject/Course Level: Electrical Engineering/Undergraduate

Grading/Final exam status: Letter grade. Final exam required.

Instructor: von Meier

Introduction to Electric Power Systems: Read Less [-]

**EL ENG 137B Introduction to Electric Power Systems 4 Units**

Terms offered: Spring 2023, Spring 2022, Spring 2021

Overview of recent and potential future evolution of electric power systems with focus on new and emerging technologies for power conversion and delivery, primarily at the distribution level. Topics include power electronics applications, solar and wind generation, distribution system design and operation, electric energy storage, information management and communications, demand response, and microgrids.

Prerequisites: EL ENG 137A or consent of instructor

**Hours & Format**

Fall and/or spring: 15 weeks - 3 hours of lecture and 1 hour of discussion per week

**Additional Details**

Subject/Course Level: Electrical Engineering/Undergraduate

Grading/Final exam status: Letter grade. Final exam required.

Instructor: von Meier

Introduction to Electric Power Systems: Read Less [-]
EL ENG 140 Linear Integrated Circuits 4 Units
Terms offered: Fall 2024, Spring 2024, Fall 2023
Single and multiple stage transistor amplifiers. Operational amplifiers. Feedback amplifiers, 2-port formulation, source, load, and feedback network loading. Frequency response of cascaded amplifiers, gain-bandwidth exchange, compensation, dominant pole techniques, root locus. Supply and temperature independent biasing and references. Selected applications of analog circuits such as analog-to-digital converters, switched capacitor filters, and comparators. Hardware laboratory and design project.

Rules & Requirements
Prerequisites: EL ENG 105
Credit Restrictions: Students will receive no credit for El Eng 140 after taking El Eng 240A.

Hours & Format
Fall and/or spring: 15 weeks - 3 hours of lecture, 1 hour of discussion, and 3 hours of laboratory per week

Additional Details
Subject/Course Level: Electrical Engineering/Undergraduate
Grading/Final exam status: Letter grade. Final exam required.
Instructors: Alon, Sanders

EL ENG 142 Integrated Circuits for Communications 4 Units
Terms offered: Spring 2024, Fall 2023, Spring 2023
Analysis and design of electronic circuits for communication systems, with an emphasis on integrated circuits for wireless communication systems. Analysis of noise and distortion in amplifiers with application to radio receiver design. Power amplifier design with application to wireless radio transmitters. Radio-frequency mixers, oscillators, phase-locked loops, modulators, and demodulators.

Rules & Requirements
Prerequisites: EECS 16A, EECS 16B, and EL ENG 105
Credit Restrictions: Students will receive no credit for El Eng 142 after taking El Eng 242A.

Hours & Format
Fall and/or spring: 15 weeks - 3 hours of lecture, 1 hour of discussion, and 3 hours of laboratory per week

Additional Details
Subject/Course Level: Electrical Engineering/Undergraduate
Grading/Final exam status: Letter grade. Final exam required.
Instructors: Keutzer, Lee, Roychowdhury, Seshia

EL ENG 143 Microfabrication Technology 4 Units
Terms offered: Fall 2024, Spring 2024, Fall 2023
Integrated circuit device fabrication and surface micromachining technology. Thermal oxidation, ion implantation, impurity diffusion, film deposition, epitaxy, lithography, etching, contacts and interconnections, and process integration issues. Device design and mask layout, relation between physical structure and electrical/mechanical performance. MOS transistors and poly-Si surface microstructures will be fabricated in the laboratory and evaluated.

Rules & Requirements
Prerequisites: PHYSICS 7B

Hours & Format
Fall and/or spring: 15 weeks - 3 hours of lecture and 3 hours of laboratory per week

Additional Details
Subject/Course Level: Electrical Engineering/Undergraduate
Grading/Final exam status: Letter grade. Final exam required.
Instructors: Alon, Sanders

EL ENG 144 Fundamental Algorithms for Systems Modeling, Analysis, and Optimization 4 Units
Terms offered: Fall 2015, Fall 2014, Fall 2013
The modeling, analysis, and optimization of complex systems requires a range of algorithms and design software. This course reviews the fundamental techniques underlying the design methodology for complex systems, using integrated circuit design as example. Topics include design flows, discrete and continuous models and algorithms, and strategies for implementing algorithms efficiently and correctly in software. Laboratory assignments and a class project will expose students to state-of-the-art tools.

Rules & Requirements
Prerequisites: EECS 16A and COMPSCI 70, or consent of instructor

Hours & Format
Fall and/or spring: 15 weeks - 4 hours of lecture per week

Additional Details
Subject/Course Level: Electrical Engineering/Undergraduate
Grading/Final exam status: Letter grade. Final exam required.
Instructors: Keutzer, Lee, Roychowdhury, Seshia

Integrated Circuits for Communications: Read More [+]
Integrated Circuits: Read Less [-]
Microfabrication Technology: Read Less [-]
Fundamental Algorithms for Systems Modeling, Analysis, and Optimization: Read Less [-]
EL ENG C145B Medical Imaging Signals and Systems 4 Units
Terms offered: Fall 2024, Fall 2023, Fall 2022
Biomedical imaging is a clinically important application of engineering, applied mathematics, physics, and medicine. In this course, we apply linear systems theory and basic physics to analyze X-ray imaging, computerized tomography, nuclear medicine, and MRI. We cover the basic physics and instrumentation that characterizes medical image as an ideal perfect-resolution image blurred by an impulse response. This material could prepare the student for a career in designing new medical imaging systems that reliably detect small tumors or infarcts.
Medical Imaging Signals and Systems: Read More [+]

Rules & Requirements
Prerequisites: Prerequisites are introductory level skills in Python/Matlab; and either EECS 16A, EECS 16B, and EL ENG 120; or MATH 54, BIO ENG 105, and BIO ENG 101

Hours & Format
Fall and/or spring: 15 weeks - 3 hours of lecture and 1 hour of discussion per week

Additional Details
Subject/Course Level: Electrical Engineering/Undergraduate
Grading/Final exam status: Letter grade. Final exam required.
Instructor: Conolly
Also listed as: BIO ENG C165
Medical Imaging Signals and Systems: Read Less [-]

EL ENG C145L Introductory Electronic Transducers Laboratory 3 Units
Terms offered: Fall 2014, Fall 2013, Fall 2012
Laboratory exercises exploring a variety of electronic transducers for measuring physical quantities such as temperature, force, displacement, sound, light, ionic potential; the use of circuits for low-level differential amplification and analog signal processing; and the use of microcomputers for digital sampling and display. Lectures cover principles explored in the laboratory exercises; construction, response and signal to noise of electronic transducers and actuators; and design of circuits for sensing and controlling physical quantities.
Introductory Electronic Transducers Laboratory: Read More [+]

Hours & Format
Fall and/or spring: 15 weeks - 2 hours of lecture and 3 hours of laboratory per week

Additional Details
Subject/Course Level: Electrical Engineering/Undergraduate
Grading/Final exam status: Letter grade. Final exam required.
Instructor: Derenko
Also listed as: BIO ENG C145L
Introductory Electronic Transducers Laboratory: Read Less [-]

EL ENG C145M Introductory Microcomputer Interfacing Laboratory 3 Units
Terms offered: Spring 2013, Spring 2012, Spring 2011
Laboratory exercises constructing basic interfacing circuits and writing 20-100 line C programs for data acquisition, storage, analysis, display, and control. Use of the IBM PC with microprogrammable digital counter/timer, parallel I/O port. Circuit components include anti-aliasing filters, the S/H amplifier, A/D and D/A converters. Exercises include effects of aliasing in periodic sampling, fast Fourier transforms of basic waveforms, the use of the Hanning filter for leakage reduction, Fourier analysis of the human voice, digital filters, and control using Fourier deconvolution. Lectures cover principles explored in the lab exercises and design of microcomputer-based systems for data acquisitions, analysis and control.
Introductory Microcomputer Interfacing Laboratory: Read More [+]

Rules & Requirements
Prerequisites: EE 16A & 16B

Hours & Format
Fall and/or spring: 15 weeks - 2 hours of lecture and 3 hours of laboratory per week

Additional Details
Subject/Course Level: Electrical Engineering/Undergraduate
Grading/Final exam status: Letter grade. Final exam required.
Instructor: Derenko
Also listed as: BIO ENG C145M
Introductory Microcomputer Interfacing Laboratory: Read Less [-]
EL ENG C145O Laboratory in the Mechanics of Organisms 3 Units
Introduction to laboratory and field study of the biomechanics of animals and plants using fundamental biomechanical techniques and equipment. Course has a series of rotations involving students in experiments demonstrating how solid and fluid mechanics can be used to discover the way in which diverse organisms move and interact with their physical environment. The laboratories emphasize sampling methodology, experimental design, and statistical interpretation of results. Latter third of course devoted to independent research projects. Written reports and class presentation of project results are required.
Laboratory in the Mechanics of Organisms: Read More [+]

Rules & Requirements
Prerequisites: INTEGBI 135 or consent of instructor. For Electrical Engineering and Computer Sciences students: EL ENG 105, EL ENG 120 or COMPSCI 184
Credit Restrictions: Students will receive no credit for C135L after taking 135L.

Hours & Format
Fall and/or spring: 15 weeks - 6 hours of laboratory, 1 hour of discussion, and 1 hour of fieldwork per week

Additional Details
Subject/Course Level: Electrical Engineering/Undergraduate
Grading/Final exam status: Letter grade. Final exam required.
Formerly known as: Integrative Biology 135L
Also listed as: BIO ENG C136L/INTEGBI C135L
Laboratory in the Mechanics of Organisms: Read Less [-]

EL ENG 146L Application Specific Integrated Circuits Laboratory 2 Units
Terms offered: Spring 2015
This is a lab course that covers the design of modern Application-Specific Integrated Circuits (ASICs). The labs lay the foundation of modern digital design by first setting-up the scripting and hardware description language base for specification of digital systems and interactions with tool flows. Software testing of digital designs is covered leading into a set of labs that cover the design flow. Digital synthesis, floorplanning, placement and routing are covered, as well as tools to evaluate design timing and power. Chip-level assembly is covered, instantiation of custom IP blocks: I/O pads, memories, PLLs, etc. The labs culminate with a project design – implementation of a 3-stage RISC-V processor with register file and caches.
Application Specific Integrated Circuits Laboratory: Read More [+]

Objectives & Outcomes
Course Objectives: This course is a one-time offering to supplement the CS150 course offered in the Fall 2014, with a lab and project section that cover the Application-Specific Integrated Circuit Design. The CS150 lectures in the Fall 2014 already covered the necessary lecture material, so students who took the CS150 lab in the Fall of 2014 will have a chance to expand their skills into the area of Application-Specific Integrated Circuit design. Hence the pre-requisite for this course is that a student has taken the CS150 course in the Fall 2014.

Rules & Requirements
Prerequisites: EECS 16B; EL ENG 105 recommended
Credit Restrictions: Students will receive no credit for Electrical Engineering 146L after taking Fall 2014 version of Electrical Engineering 141/241A.

Hours & Format
Fall and/or spring: 15 weeks - 3 hours of laboratory and 1 hour of discussion per week

Additional Details
Subject/Course Level: Electrical Engineering/Undergraduate
Grading/Final exam status: Offered for pass/not pass grade only. Final exam not required.
Instructor: Stojanovic
Application Specific Integrated Circuits Laboratory: Read Less [-]
**EL ENG 147 Introduction to Microelectromechanical Systems (MEMS) 3 Units**

Terms offered: Fall 2024, Fall 2023, Fall 2022

This course will teach fundamentals of micromachining and microfabrication techniques, including planar thin-film process technologies, photolithographic techniques, deposition and etching techniques, and the other technologies that are central to MEMS fabrication. It will pay special attention to teaching of fundamentals necessary for the design and analysis of devices and systems in mechanical, electrical, fluidic, and thermal energy/signal domains, and will teach basic techniques for multi-domain analysis. Fundamentals of sensing and transduction mechanisms including capacitive and piezoresistive techniques, and design and analysis of micromachined miniature sensors and actuators using these techniques will be covered.

Introduction to Microelectromechanical Systems (MEMS): Read More [+]

**Rules & Requirements**

**Prerequisites:** EECS 16A and EECS 16B

**Credit Restrictions:** Students will receive no credit for El Eng 147 after taking El Eng 247A.

**Hours & Format**

Fall and/or spring: 15 weeks - 3 hours of lecture and 1 hour of discussion per week

**Additional Details**

**Subject/Course Level:** Electrical Engineering/Undergraduate

**Grading/Final exam status:** Letter grade. Final exam required.

**Instructors:** Maharbiz, Nguyen, Pister

Introduction to Microelectromechanical Systems (MEMS): Read Less [-]

**EL ENG 192 Mechatronic Design Laboratory 4 Units**

Terms offered: Spring 2021, Spring 2020, Spring 2019

Design project course, focusing on application of theoretical principles in electrical engineering to control of a small-scale system, such as a mobile robot. Small teams of students will design and construct a mechatronic system incorporating sensors, actuators, and intelligence.

Mechatronic Design Laboratory: Read More [+]

**Rules & Requirements**

**Prerequisites:** EECS 16A, EECS 16B, COMPSCI 61A, COMPSCI 61B, COMPSCI 61C, and EL ENG 120

**Hours & Format**

Fall and/or spring: 15 weeks - 1.5 hours of lecture and 10 hours of laboratory per week

**Additional Details**

**Subject/Course Level:** Electrical Engineering/Undergraduate

**Grading/Final exam status:** Letter grade. Final exam required.

**Instructor:** Fearing

Mechatronic Design Laboratory: Read Less [-]

**EL ENG 194 Special Topics 1 - 4 Units**

Terms offered: Fall 2024, Spring 2024, Fall 2023

Topics will vary semester to semester. See the Electrical Engineering announcements.

Special Topics: Read More [+]

**Rules & Requirements**

**Prerequisites:** Consent of instructor

**Repeat rules:** Course may be repeated for credit when topic changes.

**Hours & Format**

Fall and/or spring: 15 weeks - 1-4 hours of lecture per week

**Additional Details**

**Subject/Course Level:** Electrical Engineering/Undergraduate

**Grading/Final exam status:** Letter grade. Final exam required.

Special Topics: Read Less [-]

**EL ENG H196A Senior Honors Thesis Research 1 - 4 Units**

Terms offered: Spring 2016, Fall 2015, Spring 2015

Thesis work under the supervision of a faculty member. A minimum of four units must be taken; the units may be distributed between one and two semesters in any way. To obtain credit a satisfactory thesis must be submitted at the end of the two semesters to the Electrical and Engineering and Computer Science Department archive. Students who complete four units and a thesis in one semester receive a letter grade at the end of H196A. Students who do not, receive an IP in H196A and must enroll in H196B.

Senior Honors Thesis Research: Read More [+]

**Rules & Requirements**

**Prerequisites:** Open only to students in the Electrical Engineering and Computer Science honors program

**Hours & Format**

Fall and/or spring: 15 weeks - 1-4 hours of independent study per week

**Additional Details**

**Subject/Course Level:** Electrical Engineering/Undergraduate

**Grading/Final exam status:** Letter grade. This is part one of a year long series course. A provisional grade of IP (in progress) will be applied and later replaced with the final grade after completing part two of the series. Final exam required.

Senior Honors Thesis Research: Read Less [-]
EL ENG H196B Senior Honors Thesis Research 1 - 4 Units
Terms offered: Spring 2016, Spring 2015, Spring 2014
Thesis work under the supervision of a faculty member. A minimum of four units must be taken; the units may be distributed between one and two semesters in any way. To obtain credit a satisfactory thesis must be submitted at the end of the two semesters to the Electrical and Engineering and Computer Science Department archive. Students who complete four units and a thesis in one semester receive a letter grade at the end of H196A. Students who do not, receive an IP in H196A and must enroll in H196B.
Senior Honors Thesis Research: Read More [+]
Rules & Requirements
Prerequisites: Open only to students in the Electrical Engineering and Computer Science honors program
Hours & Format
Fall and/or spring: 15 weeks - 1-4 hours of independent study per week
Additional Details
Subject/Course Level: Electrical Engineering/Undergraduate
Grading/Final exam status: Letter grade. This is part two of a year long series course. Upon completion, the final grade will be applied to both parts of the series. Final exam required.
Senior Honors Thesis Research: Read Less [-]

EL ENG 197 Field Study 1 - 4 Units
Terms offered: Fall 2023, Fall 2022, Fall 2021
Students take part in organized individual field sponsored programs with off-campus companies or tutoring/mentoring relevant to specific aspects and applications of computer science on or off campus. Note Summer CPT or OPT students: written report required. Course does not count toward major requirements, but will be counted in the cumulative units toward graduation.
Field Study: Read More [+]
Rules & Requirements
Prerequisites: Consent of instructor (see department adviser)
Repeat rules: Course may be repeated for credit without restriction.
Hours & Format
Fall and/or spring: 15 weeks - 1-4 hours of fieldwork per week
Summer:
6 weeks - 2.5-10 hours of fieldwork per week
8 weeks - 2-7.5 hours of fieldwork per week
Additional Details
Subject/Course Level: Electrical Engineering/Undergraduate
Grading/Final exam status: Offered for pass/not pass grade only. Final exam not required.
Field Study: Read Less [-]

EL ENG 198 Directed Group Study for Advanced Undergraduates 1 - 4 Units
Terms offered: Spring 2024, Fall 2023, Spring 2023
Group study of selected topics in electrical engineering, usually relating to new developments.
Directed Group Study for Advanced Undergraduates: Read More [+]
Rules & Requirements
Prerequisites: 2.0 GPA or better; 60 units completed
Repeat rules: Course may be repeated for credit without restriction.
Hours & Format
Fall and/or spring: 15 weeks - 1-4 hours of directed group study per week
Additional Details
Subject/Course Level: Electrical Engineering/Undergraduate
Grading/Final exam status: Offered for pass/not pass grade only. Final exam not required.
Directed Group Study for Advanced Undergraduates: Read Less [-]

EL ENG 199 Supervised Independent Study 1 - 4 Units
Terms offered: Summer 2024 10 Week Session, Spring 2023, Fall 2018
Supervised independent study. Enrollment restrictions apply.
Supervised Independent Study: Read More [+]
Rules & Requirements
Prerequisites: Consent of instructor and major adviser
Credit Restrictions: Enrollment is restricted; see the Introduction to Courses and Curricula section of this catalog.
Repeat rules: Course may be repeated for credit without restriction.
Hours & Format
Fall and/or spring: 15 weeks - 0 hours of independent study per week
Summer:
6 weeks - 1-5 hours of independent study per week
8 weeks - 1-4 hours of independent study per week
Additional Details
Subject/Course Level: Electrical Engineering/Undergraduate
Grading/Final exam status: Offered for pass/not pass grade only. Final exam not required.
Supervised Independent Study: Read Less [-]

Materials Science and Engineering Courses
Expand all course descriptions [+]
Collapse all course descriptions [-]
MAT SCI 24 Freshman Seminar 1 Unit
Terms offered: Spring 2023, Spring 2022, Spring 2020
The Freshman Seminar Program has been designed to provide new students with the opportunity to explore an intellectual topic with a faculty member in a small seminar setting. Freshman seminars are offered in all campus departments, and topics vary from department to department and semester to semester. Enrollment limited to 20 freshmen.
Freshman Seminar: Read More [+]

Hours & Format
Fall and/or spring: 15 weeks - 1 hour of lecture per week

Additional Details
Subject/Course Level: Materials Science and Engineering/Undergraduate
Grading/Final exam status: Offered for pass/not pass grade only. Final Exam To be decided by the instructor when the class is offered.
Freshman Seminar: Read Less [-]

MAT SCI 45 Properties of Materials 3 Units
Terms offered: Fall 2024, Spring 2024, Fall 2023
Application of basic principles of physics and chemistry to the engineering properties of materials. Emphasis on establishing structure, property, processing, and performance interrelationships in metals, ceramics, and polymers. While core concepts are fully covered each semester, examples and contextualization in Fall editions focuses on metals, ceramics, and functional/electronic properties and in Spring editions on polymers and soft-materials.
Properties of Materials: Read More [+]

Rules & Requirements
Prerequisites: Students should have completed high school AP or honors chemistry and physics

Hours & Format
Fall and/or spring: 15 weeks - 3 hours of lecture per week

Additional Details
Subject/Course Level: Materials Science and Engineering/Undergraduate
Grading/Final exam status: Letter grade. Final exam required.
Instructors: Martin, Messersmith
Properties of Materials: Read Less [-]

MAT SCI 45L Properties of Materials Laboratory 1 Unit
Terms offered: Fall 2024, Spring 2024, Fall 2023
This course presents laboratory applications of the basic principles introduced in the lecture-based course MSE45 – Properties of Materials.
Properties of Materials Laboratory: Read More [+]

Rules & Requirements
Credit Restrictions: Students will receive no credit for MSE 45L after taking E45L

Hours & Format
Fall and/or spring: 15 weeks - 3 hours of laboratory per week

Additional Details
Subject/Course Level: Materials Science and Engineering/Undergraduate
Grading/Final exam status: Letter grade. Final exam not required.
Instructors: Martin, Messersmith
Properties of Materials Laboratory: Read Less [-]

MAT SCI 102 Bonding, Crystallography, and Crystal Defects 3 Units
Terms offered: Fall 2024, Fall 2023, Fall 2022
Bonding in solids; classification of metals, semiconductors, and insulators; crystal systems; point, line, and planar defects in crystals; examples of crystallographic and defect analysis in engineering materials; relationship to physical and mechanical properties.
Bonding, Crystallography, and Crystal Defects: Read More [+]

Rules & Requirements
Prerequisites: MAT SCI 45

Hours & Format
Fall and/or spring: 15 weeks - 3 hours of lecture per week

Additional Details
Subject/Course Level: Materials Science and Engineering/Undergraduate
Grading/Final exam status: Letter grade. Final exam required.
Instructor: Chrzan
Bonding, Crystallography, and Crystal Defects: Read Less [-]
MAT SCI 103 Phase Transformations and Kinetics 3 Units
Terms offered: Spring 2024, Spring 2023, Spring 2022
The nature, mechanisms, and kinetics of phase transformations and microstructural changes in the solid state. Atom diffusion in solids. Phase transformations through the nucleation and growth of new matrix or precipitate phases. Martensitic transformations, spinodal decomposition. The use of phase transformations to control microstructure.

Rules & Requirements
Prerequisites: MAT SCI 102 and ENGIN 40

Hours & Format
Fall and/or spring: 15 weeks - 3 hours of lecture per week

Additional Details
Subject/Course Level: Materials Science and Engineering/Undergraduate

Grading/Final exam status: Letter grade. Alternative to final exam.

Phase Transformations and Kinetics: Read More [+]

MAT SCI 104 Materials Characterization 3 Units
Terms offered: Spring 2024, Spring 2023, Spring 2022
This 3-unit course will cover basic principles and techniques used for the characterization of engineering materials. The course is designed to introduce undergraduate students to the basic principles of structural, chemical and property characterization techniques. The course is grounded in modern x-ray diffraction and electron microscopy techniques for characterization of the chemical and structural properties of a material. The course introduces the fundamental theoretical framework for diffraction, spectrometry and imaging methods.

Objectives & Outcomes
Course Objectives: Materials characterization lies at the heart of understanding the property-structure-processing relationships of materials. The goal of the course is to prepare undergraduate students from materials science to understand the basic principles behind material characterization tools and techniques. More specifically, this class will provide students (1) a thorough introduction to the principles and practice of diffraction, (2) introductory exposure to a range of common characterization methods for the determination of structure and composition of solids. A successful student will learn (1) the theory of x-ray and electron diffraction, (2) basic elements of electron microscopy, (3) basic aspects of optical and scanning probe techniques.

Rules & Requirements
Prerequisites: MAT SCI 102. A basic knowledge of structure, bonding and crystallography will be assumed

Hours & Format
Fall and/or spring: 15 weeks - 3 hours of lecture per week

Additional Details
Subject/Course Level: Materials Science and Engineering/Undergraduate

Grading/Final exam status: Letter grade. Final exam required.

Instructors: Scott, Minor

Materials Characterization: Read Less [-]
MAT SCI 104L Materials Characterization Laboratory 1 Unit
Terms offered: Spring 2024, Spring 2023, Spring 2022
This 1-unit laboratory course covers X-ray diffraction (XRD), scanning electron microscopy (SEM), and transmission electron microscopy (TEM), as well as lab writeup protocols and academic integrity. Students will get hands-on experience using the XRD, SEM and TEM equipment to perform microstructural characterization of materials. Students will also design and run their own project on a topic of their choosing.

Course Objectives: Practical experience on the most common materials characterization equipment for structural and chemical analysis of materials. Introduction to laboratory procedures and independent projects.

Rules & Requirements
Prerequisites: MAT SCI 102; and MAT SCI 104 must be taken concurrently. A basic knowledge of structure, bonding and crystallography will be assumed. Undergraduate student in engineering, physics or chemistry

Hours & Format
Fall and/or spring: 15 weeks - 1.5 hours of laboratory and 1 hour of discussion per week

Additional Details
Subject/Course Level: Materials Science and Engineering/Undergraduate
Grading/Final exam status: Letter grade. Final exam not required.
Instructors: Scott, Minor

MAT SCI 111 Properties of Electronic Materials 4 Units
Terms offered: Spring 2024, Spring 2023, Spring 2022
Introduction to the physical principles underlying the electric properties of modern solids with emphasis on semiconductors; control of defects and impurities through physical purification, bulk and thin film crystal growth and doping processes, materials basis of electronic and optoelectronic devices (diodes, transistors, semiconductor lasers) and optical fibers; properties of metal and oxide superconductors and their applications.

Rules & Requirements
Prerequisites: PHYSICS 7A, PHYSICS 7B, and PHYSICS 7C; or PHYSICS 7A, PHYSICS 7B and consent of instructor

Hours & Format
Fall and/or spring: 15 weeks - 3 hours of lecture and 1 hour of discussion per week

Additional Details
Subject/Course Level: Materials Science and Engineering/Undergraduate
Grading/Final exam status: Letter grade. Final exam required.
Instructors: Dubon, Wu, Yao

MAT SCI 112 Corrosion (Chemical Properties) 3 Units
Terms offered: Spring 2024, Spring 2023, Spring 2022

Rules & Requirements
Prerequisites: MAT SCI 45 and ENGIN 40

Hours & Format
Fall and/or spring: 15 weeks - 3 hours of lecture per week

Additional Details
Subject/Course Level: Materials Science and Engineering/Undergraduate
Grading/Final exam status: Letter grade. Final exam required.
Instructor: Devine

Instructor: Devine
MAT SCI 113 Mechanical Behavior of Engineering Materials 3 Units
Terms offered: Fall 2024, Fall 2023, Fall 2022
This course covers elastic and plastic deformation under static/dynamic loads. Prediction/prevention of failure by yielding, fracture, fatigue, wear and environmental effects are addressed. Design issues of materials selection for load-bearing applications are discussed. Case studies of engineering failures are presented. Topics include engineering materials, structure-property relationships, mechanical behavior of metals, ceramics, polymers and composites, complex stress/strain states, stress concentrations, multiaxial loading, plasticity, yield criteria, dislocations, strengthening mechanisms, creep, fracture mechanics and fatigue.

Rules & Requirements
Prerequisites: CIV ENG C30/MEC ENG C85 and MAT SCI 45
Credit Restrictions: Students will receive no credit for 113 after taking C113 or Mechanical Engineering C124. Deficiency in C113 or Mechanical Engineering C124 maybe removed by taking 113.

Hours & Format
Fall and/or spring: 15 weeks - 3 hours of lecture per week
Additional Details
Subject/Course Level: Materials Science and Engineering/Undergraduate
Grading/Final exam status: Letter grade. Final exam required.
Instructor: Ritchie

MAT SCI 117 Properties of Dielectric and Magnetic Materials 3 Units
Terms offered: Spring 2021, Spring 2017, Spring 2011
Introduction to the physical principles underlying the dielectric and magnetic properties of solids. Processing-microstructure-property relationships of dielectric materials, including piezoelectric, pyroelectric, and ferroelectric oxides, and of magnetic materials, including hard- and soft ferromagnets, ferrites and magneto-optic and -resistive materials. The course also covers the properties of grain boundary devices (including varistors) as well as ion-conducting and mixed conducting materials for applications in various devices such as sensors, fuel cells, and electric batteries.

Rules & Requirements
Prerequisites: PHYSICS 7A, PHYSICS 7B, and PHYSICS 7C; or PHYSICS 7A, PHYSICS 7B, and consent of instructor. MAT SCI 111 is recommended

Hours & Format
Fall and/or spring: 15 weeks - 3 hours of lecture per week
Additional Details
Subject/Course Level: Materials Science and Engineering/Undergraduate
Grading/Final exam status: Letter grade. Final exam required.

Properties of Dielectric and Magnetic Materials: Read Less [-]
MAT SCI C118 Biological Performance of Materials 4 Units

Terms offered: Fall 2024, Fall 2023, Fall 2022

This course is intended to give students the opportunity to expand their knowledge of topics related to biomedical materials selection and design. Structure-property relationships of biomedical materials and their interaction with biological systems will be addressed. Applications of the concepts developed include blood-materials compatibility, biomimetic materials, hard and soft tissue-materials interactions, drug delivery, tissue engineering, and biotechnology.

Biological Performance of Materials: Read More [+]

Objectives & Outcomes

Course Objectives: The course is separated into four parts spanning the principles of synthetic materials and surfaces, principles of biological materials, biological performance of materials and devices, and state-of-the-art materials design. Students are required to attend class and master the material therein. In addition, readings from the clinical, life and materials science literature are assigned. Students are encouraged to seek out additional reference material to complement the readings assigned. A mid-term examination is given on basic principles (parts 1 and 2 of the outline). A comprehensive final examination is given as well. The purpose of this course is to introduce students to problems associated with the selection and function of biomaterials. Through class lectures and readings in both the physical and life science literature, students will gain broad knowledge of the criteria used to select biomaterials, especially in devices where the material-tissue or material-solution interface dominates performance. Materials used in devices for medicine, dentistry, tissue engineering, drug delivery, and the biotechnology industry will be addressed.

This course also has a significant design component (~35%). Students will form small teams (five or less) and undertake a semester-long design project related to the subject matter of the course. The project includes the preparation of a paper and a 20 minute oral presentation critically analyzing a current material-tissue or material-solution problem. Students will be expected to design improvements to materials and devices to overcome the problems identified in class with existing materials.

Student Learning Outcomes:

Apply math, science & engineering principles to the understanding of soft materials, surface chemistry, DLVO theory, protein adsorption kinetics, viscoelasticity, mass diffusion, and molecular (i.e., drug) delivery kinetics.

Design experiments and analyze data from the literature in the context of the class design project.

Apply core concepts in materials science to solve engineering problems related to the selection biomaterials, especially in devices where the material-tissue or material-solution interface dominates performance. Develop an understanding of the social, safety and medical consequences of biomaterial use and regulatory issues associated with the selection of biomaterials in the context of the silicone breast implant controversy and subsequent biomaterials crisis.

Work independently and function on a team, and develop solid communication skills (oral, graphic & written) through the class design project.

Understand the origin of surface forces and interfacial free energy, and how they contribute to the development of the biomaterial interface and ultimately biomaterial performance.

Rules & Requirements

Prerequisites: MAT SCI 45 and BIO ENG 103 are required. BIO ENG 102 and BIO ENG 104 are strongly recommended.
MAT SCI 122 Ceramic Processing 3 Units
Terms offered: Fall 2012, Fall 2011, Fall 2010
Powder fabrication by grinding and chemical methods, rheological behavior of powder-fluid suspensions, forming methods, drying, sintering, and grain growth. Relation of processing steps to microstructure development.

Ceramic Processing: Read More [+]

Rules & Requirements
Prerequisites: MAT SCI 45 and ENGIN 40

Hours & Format
Fall and/or spring: 15 weeks - 3 hours of lecture per week

Additional Details
Subject/Course Level: Materials Science and Engineering/Undergraduate
Grading/Final exam status: Letter grade. Final exam required.

MAT SCI 123 ELECTRONIC MATERIALS PROCESSING 4 Units
Terms offered: Spring 2022, Spring 2021, Spring 2020
This 4-unit course starts with a brief review of the fundamentals of solid-state physics including bands and defects in semiconductors and oxides, and then moves to bulk semiconductor crystals growth and processing including doping, diffusion and implantation, and then to thin film deposition and processing methods, and finishes with a discussion of materials analysis and characterization. Recent advances in nanomaterials research will also be introduced.

ELECTRONIC MATERIALS PROCESSING: Read More [+]

Objectives & Outcomes
Course Objectives:
To prepare students a) for work in semiconductor processing facilities and b) for graduate studies related to thin film processing and relevant materials science topics.
To present the relevant materials science issues in semiconductor and oxide processing.
To provide an introduction into the principles of thin film processing and related technologies.

Student Learning Outcomes:
Basic knowledge of gas kinetics and vacuum technology, including ideal gas, gas transport theory, definition, creation and measurement of vacuum.
Knowledge of electrical and optical properties of thin films.
Knowledge of the formation of p-n junction to explain the diode operation and its I-V characteristics. Understanding of the mechanisms of Hall Effect, transport, and C-V measurements, so that can calculate carrier concentration, mobility and conductivity given raw experimental data.
The ability to describe major growth techniques of bulk, thin film, and nanostructured semiconductors, with particular emphasis on thin film deposition technologies, including evaporation, sputtering, chemical vapor deposition and epitaxial growths.
To have basic knowledge of doping, purification, oxidation, gettering, diffusion, implantation, metallization, lithography and etching in semiconductor processing.
To have basic knowledge of electronic material characterization methods: x-ray diffraction, SEM and TEM, EDX, Auger, STM and AFM, Rutherford Back Scattering and SIMS, as well as optical methods including photoluminescence, absorption and Raman scattering.
To understand the concepts of bands, bandgap, to distinguish direct and indirect bandgap semiconductors. Understanding of free electron and hole doping of semiconductors to determine Fermi level position.
To understand the effect of defects in semiconductors, so that can describe their electronic and optical behaviors, and the methods to eliminate and control them in semiconductors.

Rules & Requirements
Prerequisites: MAT SCI 111, PHYSICS 7C, or consent of instructor

Hours & Format
Fall and/or spring: 15 weeks - 4 hours of lecture per week

Additional Details
Subject/Course Level: Materials Science and Engineering/Undergraduate
Grading/Final exam status: Letter grade. Final exam required.
Instructors: Wu, Yao

ELECTRONIC MATERIALS PROCESSING: Read Less [-]
MAT SCI 125 Thin-Film Materials Science 3 Units
Terms offered: Fall 2024, Fall 2023, Fall 2022
Prerequisites: Upper division or graduate standing in Engineering, Physics, Chemistry, or Chemical Engineering; and MAT SCI 45. PHYSICS 111A or PHYSICS 141A recommended
Hours & Format
Fall and/or spring: 15 weeks - 3 hours of lecture per week
Additional Details
Subject/Course Level: Materials Science and Engineering/Undergraduate
Grading/Final exam status: Letter grade. Final exam required.
Instructor: Dubon
Thin-Film Materials Science: Read Less [-]

MAT SCI 127 Introduction to Additive Manufacturing: Process, Materials and Designs 3 Units
Terms offered: Spring 2024, Spring 2023
Additive manufacturing, the industrial name of 3D printing, pertains to the general class of technologies that, using computer-created (CAD) solid models as input, creates three-dimensional (3D) artifacts through the successive formation of materials. Students will learn the engineering principles and frontiers of additive manufacturing systems and their applications to transforming the rapid prototyping to the paradigm of Additive Manufacturing (AM) for creating functional parts, materials and assembly. Students will apply their learning through class projects wherein they will design novel products via AM, design new AM systems and manufacturing strategies for novel materials. Class will also explore advanced design topics enabled by AM
Prerequisites: PHYSICS 7A (recommended), MAT SCI 45, MEC ENG C85/CIV ENG C30, or consent of instructor
Hours & Format
Fall and/or spring: 15 weeks - 3 hours of lecture per week
Additional Details
Subject/Course Level: Materials Science and Engineering/Undergraduate
Grading/Final exam status: Letter grade. Alternative to final exam.
Instructor: Zheng
Introduction to Additive Manufacturing: Process, Materials and Designs: Read Less [-]
MAT SCI 129 Experimental Materials Science of Thin Films and Coatings 3 Units
Terms offered: Spring 2022
This course covers the fundamental experimental materials science and processing of thin film and coatings that incorporates fundamental knowledge of materials transport, accumulation, defects and epitaxy. Through this course, an understanding of the fundamental physical and chemical processes which are involved in crystal growth and thin film fabrication will be gained. Important synthesis and processing techniques used for the fabrication of electronic and photonic devices will be discussed. Finally, it will provide an understanding of how material characteristics are influenced by processing and deposition conditions. This course addresses current challenges and future needs of the semiconductor and coating industries.

Objectives & Outcomes
Student Learning Outcomes: The development of proper protocols for data collection, analysis, and dissemination. To apply this knowledge to scholarly report writing and the hypothesis driven insights and conclusions. To familiarize students with some of the important experimental methods for the growth of materials. To gain an understanding of how material characteristics are influenced by processing and deposition conditions of thin films and coatings. To gain an understanding of the fundamental physical and chemical processes which are involved in crystal growth and thin film fabrication.

Rules & Requirements
Prerequisites: MAT SCI 45, MAT SCI 104, and MAT SCI 125; or consent of instructor

Hours & Format
Fall and/or spring: 15 weeks - 2 hours of lecture and 3 hours of laboratory per week

Additional Details
Subject/Course Level: Materials Science and Engineering/Undergraduate
Grading/Final exam status: Letter grade. Alternative to final exam.
Instructor: Al Balushi

Experimental Materials Science of Thin Films and Coatings: Read More [+]

MAT SCI 130 Experimental Materials Science and Design 3 Units
Terms offered: Fall 2023, Fall 2022, Fall 2021
This course provides a culminating experience for students approaching completion of the materials science and engineering curriculum. Laboratory experiments are undertaken in a variety of areas from the investigations on semiconductor materials to corrosion science and elucidate the relationships among structure, processing, properties, and performance. The principles of materials selection in engineering design are reviewed.

Rules & Requirements
Prerequisites: Senior standing or consent of instructor

Hours & Format
Fall and/or spring: 15 weeks - 2 hours of lecture and 3 hours of laboratory per week

Additional Details
Subject/Course Level: Materials Science and Engineering/Undergraduate
Grading/Final exam status: Letter grade. Final exam required.

Experimental Materials Science and Design: Read Less [-]

MAT SCI 131 Additive Manufacturing Processes and Systems for Advanced Materials 3 Units
Terms offered: Fall 2024
In this course, students will learn the engineering principles, system designs, process dynamics and construction of advanced additive fabrication systems. Students will explore the process-structure-property relationships for various commercial and custom additive manufacturing processes for polymer, metal, ceramic, composites and beyond. Additionally, students will explore the digital design and manufacturing of 3D topologies, cellular materials and metamaterials enabled by additive processes. In addition to gaining theoretical and hands-on access to AM technologies, students will apply their learning through design projects wherein they will create novel materials or engineering products via additive manufacturing processes.

Rules & Requirements
Prerequisites: MAT SCI 45, MAT SCI 104, and MAT SCI 125; or consent of instructor

Hours & Format
Fall and/or spring: 15 weeks - 3 hours of lecture and 3 hours of laboratory per week

Additional Details
Subject/Course Level: Materials Science and Engineering/Undergraduate
Grading/Final exam status: Letter grade. Final exam required.
Instructor: Zheng

Additive Manufacturing Processes and Systems for Advanced Materials: Read More [+]

Additive Manufacturing Processes and Systems for Advanced Materials: Read Less [-]
**MAT SCI 136 Materials in Energy Technologies 4 Units**
Terms offered: Fall 2021, Fall 2019, Fall 2017
In many, if not all, technologies, it is materials that play a crucial, enabling role. This course examines potentially sustainable technologies, and the materials properties that enable them. The science at the basis of selected energy technologies are examined and considered in case studies.
Materials in Energy Technologies: Read More [+]

**Rules & Requirements**

**Prerequisites:** Junior or above standing in Materials Science and Engineering or related field

**Hours & Format**

Fall and/or spring: 15 weeks - 3 hours of lecture and 1 hour of discussion per week

**Additional Details**

**Subject/Course Level:** Materials Science and Engineering/Undergraduate

**Grading/Final exam status:** Letter grade. Final exam required.

**Formerly known as:** Materials Science and Engineering 126

**MAT SCI 140 Nanomaterials for Scientists and Engineers 3 Units**
Terms offered: Spring 2022, Spring 2020, Spring 2015
This course introduces the fundamental principles needed to understand the behavior of materials at the nanometer length scale and the different classes of nanomaterials with applications ranging from information technology to biotechnology. Topics include introduction to different classes of nanomaterials, synthesis and characterization of nanomaterials, and the electronic, magnetic, optical, and mechanical properties of nanomaterials.
Nanomaterials for Scientists and Engineers: Read More [+]

**Rules & Requirements**

**Prerequisites:** PHYSICS 7C and MAT SCI 45. MAT SCI 102 recommended

**Hours & Format**

Fall and/or spring: 15 weeks - 3 hours of lecture per week

**Additional Details**

**Subject/Course Level:** Materials Science and Engineering/Undergraduate

**Grading/Final exam status:** Letter grade. Final exam required.

**Instructor:** Zheng

Nanomaterials for Scientists and Engineers: Read Less [-]
MAT SCI C157 Nanomaterials in Medicine 3 Units
Terms offered: Fall 2022, Fall 2021, Fall 2020
Nanomedicine is an emerging field involving the use of nanoscale materials for therapeutic and diagnostic purposes. Nanomedicine is a highly interdisciplinary field involving chemistry, materials science, biology and medicine, and has the potential to make major impacts on healthcare in the future. This upper division course is designed for students interested in learning about current developments and future trends in nanomedicine. The overall objective of the course is to introduce major aspects of nanomedicine including the selection, design and testing of suitable nanomaterials, and key determinants of therapeutic and diagnostic efficacy. Organic, inorganic and hybrid nanomaterials will be discussed in this course. Nanomaterials in Medicine: Read More [+]

Objectives & Outcomes
Course Objectives: To identify an existing or unmet clinical need and identify a nanomedicine that can provide a solution
To learn about chemical approaches used in nanomaterial synthesis and surface modification.
To learn how to read and critique the academic literature.
To understand the interaction of nanomaterials with proteins, cells, and biological systems.

Rules & Requirements
Prerequisites: MAT SCI 45 or consent of instructor

Hours & Format
Fall and/or spring: 15 weeks - 3 hours of lecture per week

Additional Details
Subject/Course Level: Materials Science and Engineering/Undergraduate
Grading/Final exam status: Letter grade. Final exam required.
Instructor: Messersmith
Also listed as: BIO ENG C157

MAT SCI 159 Introduction to Soft Matter 3 Units
Terms offered: Fall 2024, Fall 2023, Fall 2022
Soft matter is ubiquitous in synthetic materials and plays a central role in living systems. This course aims to provide students with an introduction to the physics that govern the structure and dynamics of soft matter systems, including polymers, colloids, surfactants, membranes, and active matter. A particular emphasis will be placed on connecting a microscopic physical picture to the emergent phenomena and properties of interest using scaling theory and statistical mechanics. Specific topics will include Brownian motion and colloidal dynamics, the depletion force, polymer chain conformation, rubber elasticity; and surfactant and liquid crystal thermodynamics.

Introduction to Soft Matter: Read More [+]

Rules & Requirements
Prerequisites: ENGIN 40, PHYSICS 5C, CHEM 120B, CHEM ENG 141, or MECH ENG 40

Hours & Format
Fall and/or spring: 15 weeks - 3 hours of lecture per week

Additional Details
Subject/Course Level: Materials Science and Engineering/Undergraduate
Grading/Final exam status: Letter grade. Alternate method of final assessment during regularly scheduled final exam group (e.g., presentation, final project, etc.).
Instructor: Omar

Introduction to Soft Matter: Read Less [-]
**MAT SCI H194 Honors Undergraduate Research 1 - 4 Units**

Terms offered: Fall 2016, Spring 2016, Fall 2015

Students who have completed a satisfactory number of advanced courses with a grade-point average of 3.3 or higher may pursue original research under the direction of one of the members of the staff. A maximum of 3 units of H194 may be used to fulfill technical elective requirements in the Materials Science and Engineering program or double majors (unlike 198 or 199, which do not satisfy technical elective requirements). Final report required.

Honors Undergraduate Research: Read More [+]

**Rules & Requirements**

**Prerequisites:** Upper division technical GPA of 3.3 or higher and consent of instructor and adviser

**Repeat rules:** Course may be repeated for credit without restriction.

**Hours & Format**

Fall and/or spring: 15 weeks - 1-4 hours of independent study per week

Summer: 8 weeks - 1.5-7.5 hours of independent study per week

**Additional Details**

**Subject/Course Level:** Materials Science and Engineering/Undergraduate

**Grading/Final exam status:** Letter grade. Final exam not required.

Honors Undergraduate Research: Read Less [-]

**MAT SCI 195 Special Topics for Advanced Undergraduates 1 Unit**

Terms offered: Spring 2012, Spring 2011, Spring 2010

Group study of special topics in materials science and engineering. Selection of topics for further study of underlying concepts and relevant literature, in consultation with appropriate faculty members.

Special Topics for Advanced Undergraduates: Read More [+]

**Rules & Requirements**

**Prerequisites:** Upper division standing and good academic standing. (2.0 gpa and above)

**Hours & Format**

Fall and/or spring: 15 weeks - 1 hour of directed group study per week

**Additional Details**

**Subject/Course Level:** Materials Science and Engineering/Undergraduate

**Grading/Final exam status:** Letter grade. Final exam required.

Special Topics for Advanced Undergraduates: Read Less [-]

**MAT SCI 198 Directed Group Studies for Advanced Undergraduates 1 - 4 Units**

Terms offered: Spring 2019, Fall 2018, Spring 2016

Group studies of selected topics.

Direct Group Studies for Advanced Undergraduates: Read More [+]

**Rules & Requirements**

**Prerequisites:** Upper division standing in Engineering

**Hours & Format**

Fall and/or spring: 15 weeks - 1-4 hours of directed group study per week

**Additional Details**

**Subject/Course Level:** Materials Science and Engineering/Undergraduate

**Grading/Final exam status:** Offered for pass/not pass grade only. Final exam not required.

Direct Group Studies for Advanced Undergraduates: Read Less [-]

**MAT SCI 199 Supervised Independent Study 1 - 4 Units**

Terms offered: Spring 2023, Fall 2022, Spring 2022

Supervised independent study. Enrollment restrictions apply; see the Introduction to Courses and Curricula section of this catalog.

Supervised Independent Study: Read More [+]

**Rules & Requirements**

**Prerequisites:** Consent of instructor and major adviser

**Credit Restrictions:** Course may be repeated for a maximum of four units per semester.

**Repeat rules:** Course may be repeated for credit without restriction.

**Hours & Format**

Fall and/or spring: 15 weeks - 1-4 hours of independent study per week

Summer: 6 weeks - 1-5 hours of independent study per week

8 weeks - 1-4 hours of independent study per week

**Additional Details**

**Subject/Course Level:** Materials Science and Engineering/Undergraduate

**Grading/Final exam status:** Offered for pass/not pass grade only. Final exam not required.

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