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 for admission directly to a joint major is closed to freshmen and junior transfer applicants. Students interested in a joint program may apply to change majors during specific times in their academic progress. 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>4</td>
</tr>
<tr>
<td>or CHEM 4A</td>
<td>General Chemistry and Quantitative Analysis</td>
<td></td>
</tr>
<tr>
<td>PHYSICS 7A &amp; PHYSICS 7B</td>
<td>Physics for Scientists and Engineers</td>
<td>12-13</td>
</tr>
<tr>
<td>&amp; PHYSICS 7C</td>
<td>and Physics for Scientists and Engineers</td>
<td></td>
</tr>
<tr>
<td>or PHYSICS 5A &amp; PHYSICS 5B</td>
<td>Introductory Mechanics and Relativity</td>
<td></td>
</tr>
<tr>
<td>&amp; PHYSICS 5BL &amp; PHYSICS 5CL</td>
<td>and Introductory Electromagnetism, Waves, and Optics</td>
<td></td>
</tr>
<tr>
<td>or PHYSICS 137A</td>
<td>Introduction to Experimental Physics I</td>
<td></td>
</tr>
<tr>
<td>MAT SCI 102</td>
<td>Properties of Materials</td>
<td>3</td>
</tr>
<tr>
<td>MAT SCI 103</td>
<td>Properties of Materials Laboratory</td>
<td>1</td>
</tr>
<tr>
<td>EL ENG 16A</td>
<td>Course Not Available</td>
<td>4</td>
</tr>
<tr>
<td>EL ENG 117</td>
<td>Course Not Available</td>
<td>4</td>
</tr>
<tr>
<td>EL ENG 118</td>
<td>Introduction to Statistical and Thermal Physics</td>
<td>4</td>
</tr>
<tr>
<td>or COMPSCI 61A</td>
<td>The Structure and Interpretation of Computer Programs</td>
<td></td>
</tr>
<tr>
<td>or PHYSICS 112</td>
<td>Introduction to Statistical and Thermal Physics</td>
<td></td>
</tr>
<tr>
<td>MAT SCI 45</td>
<td>Properties of Materials</td>
<td>3</td>
</tr>
<tr>
<td>MAT SCI 45L</td>
<td>Properties of Materials Laboratory</td>
<td>1</td>
</tr>
<tr>
<td>EL ENG 16A</td>
<td>Course Not Available</td>
<td>4</td>
</tr>
<tr>
<td>COMPSCI 61B</td>
<td>Data Structures</td>
<td>4</td>
</tr>
<tr>
<td>or COMPSCI 61BI</td>
<td>Data Structures and Programming Methodology</td>
<td></td>
</tr>
<tr>
<td>COMPSCI 61C</td>
<td>Great Ideas of Computer Architecture (Machine Structures)</td>
<td>4</td>
</tr>
<tr>
<td>or COMPSCI 61CM</td>
<td>Machine Structures (Lab-Centric)</td>
<td></td>
</tr>
<tr>
<td>or EL ENG 16B</td>
<td>Designing Information Devices and Systems II</td>
<td>4</td>
</tr>
</tbody>
</table>
| 1 CHEM 4A is intended for students majoring in chemistry or a closely-related field.

Upper Division Requirements

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>EECS 151</td>
<td>Introduction to Digital Design and Integrated Circuits (must also take EECS 151LA or EECS 151LB)</td>
<td>3-4</td>
</tr>
<tr>
<td>or EL ENG 140</td>
<td>Linear Integrated Circuits</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</td>
<td>Materials Characterization</td>
<td>4</td>
</tr>
<tr>
<td>MAT SCI 130</td>
<td>Experimental Materials Science and Design</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>or EL EN 126</td>
<td>Probability and Random Processes</td>
<td>4</td>
</tr>
<tr>
<td>Upper division technical electives: two courses</td>
<td>6-8</td>
<td></td>
</tr>
<tr>
<td>Select at least 3 units from the MAT SCI 120 series</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Select one of the following: EECS 151+EECS 151LA, EECS 151+EECS 151LB, EL ENG 118, EL ENG 143</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

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 (http://engineering.berkeley.edu/academics/undergraduate-programs) 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 a maximum of four semesters to complete their degree requirements. (Note: junior transfers admitted missing three or more courses from the lower division curriculum are allowed five semesters.) 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 (http://engineering.berkeley.edu/academics/undergraduate-guide) as they complete degree requirements.

7. Complete the lower division program before enrolling in upper division engineering 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. Follow these guidelines to fulfill this requirement:

1. Complete a minimum of six courses from the approved Humanities' Social Sciences (H/SS) lists (http://engineering.berkeley.edu/hssreq).

2. Courses must be a minimum of 3 semester units (or 4 quarter units).

3. Two of the six courses must fulfill the college's Reading and Composition (R&C) requirement. These courses must be taken for a letter grade (C- or better required) and must be completed by no later than the end of the sophomore year (fourth semester of enrollment). The first half of R&C, the “A” course, must be completed by the end of the freshman year; the second half of R&C, the “B” course, must be completed by no later than the end of the sophomore year. Use the Class Schedule (http://classes.berkeley.edu) to view R&C courses offered in a given semester. View the list of exams (http://engineering.berkeley.edu/academics/undergraduate-guide/exams) that can be applied toward the first half of the R&C requirement. Note: Only the first half of R&C can be fulfilled with an AP or IB exam score. Test scores do not fulfill the second half of the R&C requirement for College of Engineering students.

4. The four additional courses must be chosen within College of Engineering guidelines from the H/SS lists (see below). These courses may be taken on a Pass/Not Passed basis (P/NP).

5. Two of the six courses must be upper division (courses numbered 100-196).

6. One of the six courses must satisfy the campus American Cultures requirement. For detailed lists of courses that fulfill American Cultures requirements, visit the American Cultures (http://guide.berkeley.edu/undergraduate/colleges-schools/engineering/american-cultures-requirement) site.

7. A maximum of two exams (Advanced Placement, International Baccalaureate, or A-Level) may be used toward completion of the H/SS requirement. View the list of exams (http://engineering.berkeley.edu/academics/undergraduate-guide/exams) that can be applied toward H/SS requirements.

8. Courses may fulfill multiple categories. For example, CY PLAN 118AC (http://guide.berkeley.edu/search/?P=CY%20PLAN%20118AC) satisfies both the American Cultures requirement and one upper division H/SS requirement.

9. No courses offered by any engineering department other than BIO ENG 100 (http://guide.berkeley.edu/search/?P=BIO%20ENG%20100), COMPSCI C79 (http://guide.berkeley.edu/search/?P=COMPSCI%20C79), ENGIN 125 (http://guide.berkeley.edu/search/?P=ENGIN%20125), ENGIN 157AC (http://guide.berkeley.edu/search/?P=ENGIN%20157AC),
and MEC ENG 191K (http://guide.berkeley.edu/search/?P=MEC %20ENG%20191K) may be used to complete H/SS requirements.

10. Foreign language courses may be used to complete H/SS requirements. View the list of language options (http://guide.berkeley.edu/undergraduate/colleges-schools/engineering/approved-foreign-language-courses).

11. Courses numbered 97, 98, 99, or above 196 may not be used to complete any H/SS requirement.

12. The College of Engineering uses modified versions of five of the College of Letters and Science (L&S) breadth requirements lists to provide options to our students for completing the H/SS requirement. The five areas are:

- Arts and Literature
- Historical Studies
- International Studies
- Philosophy and Values
- Social and Behavioral Sciences

Within the guidelines above, choose courses from any of the Breadth areas listed above. (Please note that you cannot use courses on the Biological Science or Physical Science Breadth list to complete the H/SS requirement.) To find course options, go to the Class Schedule (http://classes.berkeley.edu), (http://classes.berkeley.edu/search/class) select the term of interest, and use the Breadth Requirements (https://ls.berkeley.edu/sites/default/files/breadth_search_annotation_in_guide.png) filter.

Class Schedule Requirements

- Minimum units per semester: 12.0
- Maximum units per semester: 20.5
- Minimum technical courses: College of Engineering undergraduates must enroll each semester in no fewer than two technical courses (of a minimum of 3 units each) required of the major program of study in which the student is officially declared. (Note: For most majors, normal progress will require enrolling in 3-4 technical courses each 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 (Grade) Requirements

- A minimum overall and semester grade point average of 2.00 (C average) is required of engineering undergraduates. Students will be subject to 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 is needed to earn a Bachelor of Science in Engineering.

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 program (https://engineering.berkeley.edu/academics/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 towards the 120 units.
- A maximum of 4 units of physical education from any school attended will count towards the 120 units.
- Students may receive unit credit for courses graded P (including P/NP units taken through EAP) up to a limit of one-third of the total units taken and passed on the Berkeley campus at the time of graduation.

Normal Progress

Students in the College of Engineering must enroll in a full-time program and make normal progress each semester toward the bachelor's degree. The continued enrollment of students who fail to achieve minimum academic progress shall be subject to the approval of the dean. (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 (http://guide.berkeley.edu/undergraduate/colleges-schools/natural-resources/entry-level-writing-requirement)

All students who will enter the University of California as freshmen must demonstrate their command of the English language by fulfilling the Entry Level Writing Requirement. Satisfaction of this requirement is also a prerequisite to enrollment in all reading and composition courses at UC Berkeley.

American History and American Institutions (http://guide.berkeley.edu/undergraduate/colleges-schools/natural-resources/amERICAN-history-institutions-requirement)

The American History and Institutions 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 (http://guide.berkeley.edu/undergraduate/colleges-schools/natural-resources/american-cultures-requirement)

American Cultures (AC) is the one requirement that all undergraduate students at UC Berkeley need to take and pass in order to graduate. The requirement offers an exciting intellectual environment centered on the study of race, ethnicity, and culture in the United States. AC courses offer students opportunities to be part of research-led, highly accomplished teaching environments, grappling with the complexity of American Culture.

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</th>
<th>Units</th>
<th>Spring</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHEM 1A &amp; CHEM 1AL, or CHEM 4A</td>
<td>4</td>
<td>MATH 1B</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>MATH 1A</td>
<td>4</td>
<td>PHYSICS 7A or 5A</td>
<td>3-4</td>
<td></td>
</tr>
</tbody>
</table>
### Electrical Engineering and Computer Sciences/Materials Science and Engineering Joint Major

**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

**ECE**

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.

**CSE**

1. An ability to apply knowledge of computing and mathematics appropriate to the program’s student outcomes and to the discipline.

2. An ability to analyze a problem, and identify and define the computing requirements appropriate to its solution.

3. An ability to design, implement, and evaluate a computer-based system, process, component, or program to meet desired needs.

4. An ability to function effectively on teams to accomplish a common goal.

5. An understanding of professional, ethical, legal, security and social issues and responsibilities.

6. An ability to communicate effectively with a range of audiences.

7. An ability to analyze the local and global impact of computing on individuals, organizations, and society.

8. Recognition of the need for and an ability to engage in continuing professional development.

9. An ability to use current techniques, skills, and tools necessary for computing practice.

#### 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. 19)

Electrical Engineering Courses
Expand all course descriptions [+ Collapse all course descriptions [-]
EL ENG 25 What Electrical Engineers Do--Feedback from Recent Graduates 1 Unit
Offered through: Electrical Engin and Computer Sci
Terms offered: Fall 2011
A Berkeley Electrical Engineering and Computer Sciences degree opens the door to many opportunities, but what exactly are they? Graduation is only a few years away and it's not too early to find out. In this seminar students will hear from practicing engineers who recently graduated. What are they working on? Are they working in a team? What do they wish they had learned better? How did they find their jobs?
What Electrical Engineers Do--Feedback from Recent Graduates: Read More [+]

Hours & Format
Fall and/or spring: 15 weeks - 1 hour of lecture 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: Boser
What Electrical Engineers Do--Feedback from Recent Graduates: Read Less [-]

EL ENG 39 Freshman/Sophomore Seminar 2 - 4 Units
Offered through: Electrical Engin and Computer Sci
Terms offered: Fall 2019, Fall 2018, Fall 2017
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 - 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 42 Introduction to Digital Electronics 3 Units
Offered through: Electrical Engin and Computer Sci
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: The grading option will be decided by the instructor when the class is offered. Final exam required.
Introduction to Digital Electronics: Read Less [-]
EL ENG 43 Introductory Electronics Laboratory 1 Unit
Offered through: Electrical Engin and Computer Sci
Terms offered: Fall 2013, Summer 2013 8 Week Session, Spring 2013
Using and understanding electronics laboratory equipment such as oscilloscope, power supplies, function generator, multimeter, curve-tracer, and RLC-meter. Includes a term project of constructing and testing a robot or other appropriate electromechanical device.
Introductory Electronics Laboratory: Read More [+]

Rules & Requirements

Prerequisites: 42 (may be taken concurrently) or equivalent or consent of instructor

Hours & Format

Fall and/or spring: 15 weeks - 3 hours of laboratory per week
Summer: 8 weeks - 3.5 hours of laboratory 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.

Introductory Electronics Laboratory: Read Less [-]

EL ENG 49 Electronics for the Internet of Things 4 Units
Offered through: Electrical Engin and Computer Sci
Terms offered: Fall 2019, 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: Engineering 7 or Computer Science 10 or equivalent background in computer programming (including Computer Science 61A, Data Science 8) 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
Offered through: Electrical Engin and Computer Sci
Terms offered: Fall 2018, Fall 2017, Spring 2016
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
Offered through: Electrical Engin and Computer Sci
Terms offered: Spring 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
Offered through: Electrical Engin and Computer Sci
Terms offered: Fall 2016, Spring 2016, Fall 2015
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
Offered through: Electrical Engin and Computer Sci
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.

EL ENG 105 Microelectronic Devices and Circuits 4 Units
Offered through: Electrical Engin and Computer Sci
Terms offered: Fall 2019, Spring 2019, Fall 2018
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: EE 16A & B

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 C106A Introduction to Robotics 4 Units
Offered through: Electrical Engin and Computer Sci
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: EE 120 or equivalent, 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
Offered through: Electrical Engin and Computer Sci
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: Electrical Engineering C106A/Bioengineering C125 or consent of the instructor

EL ENG 117 Electromagnetic Fields and Waves 4 Units
Offered through: Electrical Engin and Computer Sci
Terms offered: Spring 2017, Spring 2016
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: Electrical Engineering 16B, Mathematics 53, 54, Physics 7B, or equivalent that covers AC circuits and electromagnetics up to Maxwell’s equations

EL ENG 113 Power Electronics 4 Units
Offered through: Electrical Engin and Computer Sci
Terms offered: Fall 2019, Spring 2019, Spring 2018
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: 105 or consent of instructor

EL ENG 118 Introduction to Optical Engineering 3 Units
Offered through: Electrical Engin and Computer Sci
Terms offered: Spring 2019, Fall 2017, Fall 2016
Introduction to Optical Engineering: Read More [+]
Rules & Requirements
Prerequisites: Math 53, and EE 16AB 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.

EL ENG 118 Introduction to Optical Engineering 3 Units
Offered through: Electrical Engin and Computer Sci
Terms offered: Spring 2019, Fall 2017, Fall 2016
Introduction to Optical Engineering: Read More [+]
Rules & Requirements
Prerequisites: Math 53, and EE 16AB 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.
EL ENG 120 Signals and Systems 4 Units
Offered through: Electrical Engin and Computer Sci
Terms offered: Fall 2019, Spring 2019, Fall 2018
Continuous and discrete-time transform analysis techniques with
illustrative applications. Linear and time-invariant systems, transfer
functions. Fourier series, Fourier transform, Laplace and Z-transforms.
Sampling and reconstruction. Solution of differential and difference
equations using transforms. Frequency response, Bode plots, stability
analysis. Illustrated by analysis of communication systems and feedback
control systems.
Rules & Requirements
Prerequisites: EE 16A and 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 More [+]
Rules & Requirements
Prerequisites: EE 16A and 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
Offered through: Electrical Engin and Computer Sci
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.
Rules & Requirements
Prerequisites: EE 16 A & B; CS 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 More [+]
Rules & Requirements
Prerequisites: EE 16 A & B; CS 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
Offered through: Electrical Engin and Computer Sci
Terms offered: Spring 2019, Spring 2018, Spring 2017
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.
Rules & Requirements
Prerequisites: Computer Science 70. Computer Science 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 Communication Networks: Read More [+]
Rules & Requirements
Prerequisites: 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.
Digital Signal Processing: Read More [+]
Digital Signal Processing: Read Less [-]
**EL ENG 126 Probability and Random Processes 4 Units**
Offered through: Electrical Engin and Computer Sci
Terms offered: Spring 2017, Fall 2016, Spring 2016
Probability and Random Processes: Read More [+]

**Rules & Requirements**
Prerequisites: EE 16A and 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 130 Integrated-Circuit Devices 4 Units**
Offered through: Electrical Engin and Computer Sci
Terms offered: Fall 2019, Spring 2019, Fall 2018
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.
Integrated-Circuit Devices: Read More [+]

**Rules & Requirements**
Prerequisites: EE 16A and 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.

**EL ENG 129 Neural and Nonlinear Information Processing 3 Units**
Offered through: Electrical Engin and Computer Sci
Terms offered: Spring 2010, Fall 2009, Spring 2009
Principles of massively parallel real-time computation, optimization, and information processing via nonlinear dynamics and analog VLSI neural networks. Applications selected from image processing, pattern recognition, feature extraction, motion detection, data compression, secure communication, bionic eye, auto waves, and Turing patterns.
Neural and Nonlinear Information Processing: Read More [+]

**Rules & Requirements**
Prerequisites: 120 or consent of instructor

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

**Additional Details**
Subject/Course Level: Electrical Engineering/Undergraduate
Grading/Final exam status: Letter grade. Final exam not required.
Instructor: Chua

**EL ENG C128 Feedback Control Systems 4 Units**
Offered through: Electrical Engin and Computer Sci
Terms offered: Fall 2019, Spring 2019, Fall 2018
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: EE 16A and either ME 132 or EE 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 134 Fundamentals of Photovoltaic Devices 4 Units
Offered through: Electrical Engin and Computer Sci
Terms offered: Spring 2019, Spring 2018, Spring 2017
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.
Fundamentals of Photovoltaic Devices: Read More [+]

Rules & Requirements

Prerequisites: EE 16A and 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.
Instructor: Arias

Fundamentals of Photovoltaic Devices: Read Less [-]

EL ENG 137B Introduction to Electric Power Systems 4 Units
Offered through: Electrical Engin and Computer Sci
Terms offered: Spring 2019, Spring 2018, Spring 2017
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.
Introduction to Electric Power Systems: Read More [+]

Rules & Requirements

Prerequisites: Electrical Engineering 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 137A Introduction to Electric Power Systems 4 Units
Offered through: Electrical Engin and Computer Sci
Terms offered: Fall 2019, Fall 2018, Fall 2017
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.
Introduction to Electric Power Systems: Read More [+]

Rules & Requirements

Prerequisites: 16A & 16B or consent of instructor; Physics 7B

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
Offered through: Electrical Engin and Computer Sci
Terms offered: Fall 2019, Fall 2018, Spring 2018
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.
Linear Integrated Circuits: Read More [+]

Rules & Requirements

Prerequisites: Electrical Engineering 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

Linear Integrated Circuits: Read Less [-]
EL ENG 142 Integrated Circuits for Communications 4 Units
Offered through: Electrical Engin and Computer Sci
Terms offered: Fall 2019, Fall 2018, Fall 2017
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.
Integrated Circuits for Communications: Read More [+]

Rules & Requirements
Prerequisites: EE 16A & B; EE 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.
Integrated Circuits for Communications: Read Less [-]

EL ENG 143 Microfabrication Technology 4 Units
Offered through: Electrical Engin and Computer Sci
Terms offered: Fall 2019, Spring 2019, Fall 2018
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.
Microfabrication Technology: Read More [+]

Rules & Requirements
Prerequisites: Physics 7B or equivalent

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: Keutzer, Lee, Roychowdhury, Seshia
Microfabrication Technology: Read Less [-]

EL ENG 144 Fundamental Algorithms for Systems Modeling, Analysis, and Optimization 4 Units
Offered through: Electrical Engin and Computer Sci
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.
Fundamental Algorithms for Systems Modeling, Analysis, and Optimization: Read More [+]

Rules & Requirements
Prerequisites: EE 16A; Computer Science 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
Fundamental Algorithms for Systems Modeling, Analysis, and Optimization: Read Less [-]
EL ENG C145B Medical Imaging Signals and Systems 4 Units
Offered through: Electrical Engin and Computer Sci
Terms offered: Fall 2019, Fall 2018, Fall 2017
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.

Rules & Requirements
Prerequisites: Electrical Engineering 16A and 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.
Instructor: Conolly
Also listed as: BIO ENG C165

EL ENG C145L Introductory Electronic Transducers Laboratory 3 Units
Offered through: Electrical Engin and Computer Sci
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 [+]

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: Derenzo
Also listed as: BIO ENG C145L

EL ENG C145M Introductory Microcomputer Interfacing Laboratory 3 Units
Offered through: Electrical Engin and Computer Sci
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 Hamming 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: Derenzo
Also listed as: BIO ENG C145M
EL ENG C145O Laboratory in the Mechanics of Organisms 3 Units
Offered through: Electrical Engin and Computer Sci
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.

Rules & Requirements
Prerequisites: Integrative Biology 135 or consent of instructor; for Electrical Engineering and Computer Science students, Electrical Engineering 105, 120 or Computer Science 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

EL ENG 146L Application Specific Integrated Circuits Laboratory 2 Units
Offered through: Electrical Engin and Computer Sci
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.

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: Electrical Engineering 40; Electrical Engineering 105 recommended and Computer Science 150 (taken Fall 2014) - mandatory
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**
Offered through: Electrical Engin and Computer Sci
Terms offered: Fall 2019, Fall 2018, Fall 2017
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:** Electrical Engineering 16A and 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 [-]

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**EL ENG 192 Mechatronic Design Laboratory 4 Units**
Offered through: Electrical Engin and Computer Sci
Terms offered: Spring 2019, Spring 2018, Spring 2017
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:** EE120, EE16A+EE16B, CS61ABC

**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 [-]

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**EL ENG 194 Special Topics 1 - 4 Units**
Offered through: Electrical Engin and Computer Sci
Terms offered: Fall 2018, Spring 2018, Spring 2017
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
Offered through: Electrical Engin and Computer Sci
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
Offered through: Electrical Engin and Computer Sci
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
Offered through: Electrical Engin and Computer Sci
Terms offered: Spring 2018, Spring 2016, Fall 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 198 Directed Group Study for Advanced Undergraduates 1 - 4 Units
Offered through: Electrical Engin and Computer Sci
Terms offered: Fall 2019, Spring 2019, Fall 2018
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

Offered through: Electrical Engin and Computer Sci
Terms offered: Fall 2019, Fall 2018, Spring 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 45 Properties of Materials 3 Units

Terms offered: Fall 2019, Spring 2019, Fall 2018
Application of basic principles of physics and chemistry to the engineering properties of materials. Special emphasis devoted to relation between microstructure and the mechanical properties of metals, concrete, polymers, and ceramics, and the electrical properties of semiconducting materials. Sponsoring Department: Materials Science and Engineering
Properties of Materials: Read More [+]

Rules & Requirements

Prerequisites: Physics 7A (may be taken concurrently)

Credit Restrictions: Students will receive no credit for MSE 45 after taking E45

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 2019, Spring 2019, Fall 2018
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 2019, Fall 2018, Fall 2017
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: Engineering 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

MAT SCI 103 Phase Transformations and Kinetics 3 Units
Terms offered: Spring 2019, Spring 2018, Spring 2017
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.
Phase Transformations and Kinetics: Read More [+]
Rules & Requirements
Prerequisites: 102 and Engineering 115

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: Gronsky

MAT SCI 104 Materials Characterization 4 Units
Terms offered: Spring 2019, Spring 2018, Spring 2017
Materials Characterization: Read More [+]
Rules & Requirements
Prerequisites: 102

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: Gronsky

MAT SCI 111 Properties of Electronic Materials 4 Units
Terms offered: Spring 2019, Spring 2018, Spring 2017
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.
Properties of Electronic Materials: Read More [+]
Rules & Requirements
Prerequisites: Physics 7A-7B-7C or Physics 7A-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
Properties of Electronic Materials: Read Less [-]
**MAT SCI 112 Corrosion (Chemical Properties) 3 Units**
Terms offered: Spring 2019, Spring 2018, Spring 2017

Corrosion (Chemical Properties): Read More [+]

Rules & Requirements
Prerequisites: Engineering 45 and Engineering 115

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

Corrosion (Chemical Properties): Read Less [-]

**MAT SCI 113 Mechanical Behavior of Engineering Materials 3 Units**
Terms offered: Fall 2019, Fall 2018, Fall 2017
This course covers elastic and plastic deformation under static and dynamic loads. Prediction and prevention of failure by yielding, fracture, fatigue, wear and environmental factors are addressed. Design issues pertaining to materials selection for load bearing applications are discussed. Case studies of engineering failures are presented. Topics include engineering materials, structure-property relationships, materials selection for design, mechanical behavior of polymers and design of plastic components, complex states of stress and strain, elastic deformation and multiaxial loading, plastic deformation and yield criteria, dislocation plasticity and strengthening mechanisms, creep, effects of stress concentrations, fracture, fatigue, and contact stresses.

Mechanical Behavior of Engineering Materials: Read More [+]

Rules & Requirements
Prerequisites: C30/Mechanical Engineering C85 and Engineering 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

Mechanical Behavior of Engineering Materials: Read Less [-]

**MAT SCI 117 Properties of Dielectric and Magnetic Materials 3 Units**
Terms offered: Spring 2017, Spring 2011, Fall 2010
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.

Properties of Dielectric and Magnetic Materials: Read More [+]

Rules & Requirements
Prerequisites: Physics 7A-7B-7C or Physics 7A-7B and consent of instructor; 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 2019, Fall 2018, Fall 2017
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.

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.
- Understanding of 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: Engin 45; BioE 103 or equivalent; BioE 102 and BioE 104 recommended

MAT SCI 120 Materials Production 3 Units
Terms offered: Fall 2019, Fall 2018, Fall 2017

Materials Production: Read More [+]

Rules & Requirements

Prerequisites: Engineering 115, Mechanical Engineering 40, Chemical Engineering 141, Chemistry 120B or equivalent thermodynamics course

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.

Materials Production: Read Less [-]

MAT SCI 121 Metals Processing 3 Units
Terms offered: Spring 2019, Spring 2015, Spring 2014
The principles of metals processing with emphasis on the use of processing to establish microstructures which impart desirable engineering properties. The techniques discussed include solidification, thermal and mechanical processing, powder processing, welding and joining, and surface treatments.

Metals Processing: Read More [+]

Rules & Requirements

Prerequisites: Engineering 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: Gronsky

Metals Processing: Read Less [-]
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: Engineering 45, 115

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.

Ceramic Processing: Read Less [-]

MAT SCI 123 ELECTRONIC MATERIALS PROCESSING 4 Units
Terms offered: Fall 2019, Spring 2019, Fall 2018
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: MSE 111 or 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 2019, Spring 2016, Spring 2015
Deposition, processing, and characterization of thin films and their technological applications. Physical and chemical vapor deposition methods, Thin-film nucleation and growth. Thermal and ion processing. Microstructural development in epitaxial, polycrystalline, and amorphous films. Thin-film characterization techniques. Applications in information storage, integrated circuits, and optoelectronic devices. Laboratory demonstrations.

Rules & Requirements
Prerequisites: Upper division or graduate standing in engineering, physics, chemistry, and chemical engineering; Engineering 45 required; 111 or Physics 141A recommended

Additional Details
Fall and/or spring: 15 weeks - 3 hours of lecture per week
Instructor: Dubon

MAT SCI 136 Materials in Energy Technologies 4 Units
Terms offered: Fall 2019, Fall 2017, Fall 2015
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.

Rules & Requirements
Prerequisites: Junior or above standing in Materials Science and Engineering or related field

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

MAT SCI 140 Nanomaterials for Scientists and Engineers 3 Units
Terms offered: Spring 2015, Spring 2013, Spring 2012
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.

Rules & Requirements
Prerequisites: 102 or equivalent recommended; Physics 7C and Engineering 45 required

Additional Details
Fall and/or spring: 15 weeks - 3 hours of lecture and 1 hour of discussion per week
Instructor: Minor
MAT SCI C150 Introduction to Materials Chemistry 3 Units
The application of basic chemical principles to problems in materials discovery, design, and characterization will be discussed. Topics covered will include inorganic solids, nanoscale materials, polymers, and biological materials, with specific focus on the ways in which atomic-level interactions dictate the bulk properties of matter.

Introduction to Materials Chemistry: Read More [+]

Rules & Requirements
Prerequisites: 104A; 104B 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.

Also listed as: CHEM C150

Introduction to Materials Chemistry: Read Less [-]

MAT SCI 151 Polymeric Materials 3 Units
Terms offered: Spring 2019, Spring 2018, Spring 2017
This course is designed for upper division undergraduate and graduate students to gain a fundamental understanding of the science of polymeric materials. Beginning with a treatment of ideal polymeric chain conformations, it develops the thermodynamics of polymer blends and solutions, the modeling of polymer networks and gels, the dynamics of polymer chains, and the morphologies of thin films and other dimensionally-restricted structures relevant to nanotechnology.
Polymeric Materials: Read More [+]

Rules & Requirements
Prerequisites: Chemistry 1A or Engineering 5. 103 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.
Instructor: Xu
Polymeric Materials: 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: Fall 2019, Spring 2019, Fall 2018
Group studies of selected topics.
Directed 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.

MAT SCI 199 Supervised Independent Study 1 - 4 Units
Terms offered: Fall 2019, Spring 2019, Fall 2016
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.