2021-2022 Academic Calendar

Note: Dates subject to change without notice.

<table>
<thead>
<tr>
<th></th>
<th>Fall 2021</th>
<th>Winter 2022</th>
<th>Spring 2022</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quarter begins</td>
<td>September 19, 2021</td>
<td>January 3, 2022</td>
<td>March 28, 2022</td>
</tr>
<tr>
<td>New Student Convocation</td>
<td>September 20, 2021</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre-instruction Activities</td>
<td>September 20-22, 2021</td>
<td></td>
<td></td>
</tr>
<tr>
<td>First day of instruction</td>
<td>September 23, 2021</td>
<td>January 3, 2022</td>
<td>March 28, 2022</td>
</tr>
<tr>
<td>Last day of instruction</td>
<td>December 3, 2021</td>
<td>March 11, 2022</td>
<td>June 3, 2022</td>
</tr>
<tr>
<td>Final examinations</td>
<td>December 4-10, 2021</td>
<td>March 12-18, 2022</td>
<td>June 4-10, 2022</td>
</tr>
<tr>
<td>Quarter ends</td>
<td>December 10, 2021</td>
<td>March 18, 2021</td>
<td>June 10, 2022</td>
</tr>
<tr>
<td>Commencement</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2021-2022 Campus Holidays Observed

Veterans’ Day: ......................... November 11, 2021
Thanksgiving: ........................ November 25-26, 2021
Christmas: ............................ December 23-24, 2021
New Year: ............................. December 30-31, 2021
Martin Luther King, Jr. Day: .... January 17, 2022
Presidents’ Day: ..................... February 21, 2022
Cesar Chavez Holiday: ............ March 25, 2022
Memorial Day: ........................ May 30, 2022
Independence Day: ................... July 4, 2022
Labor Day: ............................ September 5, 2022

Produced by the College of Engineering, Student Advising Division
Glenn Beltz, Associate Dean for Undergraduate Studies
Andrew Masuda, Director of Marketing

This publication is available at:
https://engineering.ucsb.edu/undergraduate/academic-advising/gear-publications

All announcements herein are subject to revision without notice.

EQUAL OPPORTUNITY AND NONDISCRIMINATION

The University of California, in accordance with applicable Federal and State law and University policy, does not discriminate on the basis of race, color, national origin, religion, sex, gender identity, pregnancy1, disability, age, medical condition (cancer related), ancestry, marital status, citizenship, sexual orientation, or status as a Vietnam-era veteran or special disabled veteran. The University also prohibits sexual harassment. This nondiscrimination policy covers admission, access, and treatment in University programs and activities.

Inquiries regarding the University’s student-related nondiscrimination policies may be directed to the Director of Equal Opportunity at (805) 893-3089.

1 Pregnancy includes pregnancy, childbirth, and medical conditions related to pregnancy or childbirth.
General Engineering Academic Requirements

College of Engineering • University of California • Santa Barbara

Volume 12, Summer 2021

Requirements and policies in the GEAR are subject to change each academic year.
Welcome to the College of Engineering at UC Santa Barbara. There are many reasons we are one of the top engineering schools in the nation. We bring together an amazing faculty, the members of which are highly acclaimed in the scientific communities in which they work. UCSB professors are, in fact, among the most cited by their colleagues worldwide, a testament to the quality and creativity of their research. A high percentage of the faculty has been elected to the prestigious National Academy of Sciences and National Academy of Engineering. We have six Nobel Prize winners on this campus, five of whom are faculty in engineering and the sciences. We’re also home to an amazing group of smart, accomplished, high-energy students. These more than 1,500 undergraduates, pursuing a variety of interests, contribute greatly to the quality of the learning environment as well as to the overall richness of campus life.

We have crafted courses that balance theory and applied science so our students are well prepared for successful careers in academia and in industry. Students especially interested in engineering and industry can take advantage of our Technology Management Program. Through coursework and “real world” experiences, the program gives our students insight into the world of technology from a business perspective. We want our students to understand what transforms a good technical idea into a good business idea. We want to give them a head start at attaining leadership positions in the technology business sector.

With a thriving interdisciplinary environment, our campus culture fosters creativity and discovery. A truly interdisciplinary culture allows all sorts of ideas to cross-fertilize and makes it easy for faculty to work effectively between disciplines to tackle big questions. Visiting scholars tell us they don’t often see the kind of openness among departments and ease of collaboration that they find here.

As part of the prestigious and well-established University of California system, we have the resources as well as the breadth and depth of talent to pursue new fields of scientific inquiry. We also bring an entrepreneurial attitude to our research, focusing on applications as much as discovery.

Our leading programs in areas as diverse as biotechnology, communications, computer security, materials, nanotechnology, networking, and photonic devices attest to the success of this approach.

At the core of this activity are our students, our central purpose. We encourage you to pursue every opportunity, both inside and outside the classroom, to enhance your education. We have a talented and wise faculty and staff, equipped with extensive knowledge and diverse experience, to help you make decisions about courses and other activities as you pursue your degree. We look forward to having you in our classes, laboratories, and offices as you discover where your interests lead you.

Glenn Beltz
Associate Dean for
Undergraduate Studies
**Table of Contents**

Message from the Associate Dean ........................................... 2

**College Overview**
Honors Programs ..................................................................... 4
Education Abroad Program ..................................................... 4
Student Organizations ............................................................. 4
Change of Major and Change of College ............................... 5
Degree Requirements ............................................................ 5
Minimal Progress Requirements and College Policy .......... 6
Five-Year B.S./M.S. Programs .................................................. 6

**General University Requirements** .............................. 10
UC Entry Level Writing Requirement .................................. 10
American History and Institutions Requirement ............ 10

**College General Education Requirements** ............. 10
General Subject Area Requirements .................................. 11
Special Subject Area Requirements
  Writing Requirement ..................................................... 11
  Ethnicity Requirement ................................................... 11
  European Traditions/World Cultures Requirement .......... 11
General Education Course Listing .................................... 12
Checklist of General Education Requirements ............. 21

**Department and Program Information**
Chemical Engineering ......................................................... 22
Computer Engineering ........................................................ 25
Computer Science ............................................................... 26
Electrical and Computer Engineering .................................. 30
Engineering Sciences .......................................................... 37
Materials ............................................................................. 38
Mechanical Engineering ...................................................... 40
Technology Management Program .................................... 56

**Major Requirements (2021-2022)**
Chemical Engineering ......................................................... 46
Computer Engineering ........................................................ 48
Computer Science ............................................................... 50
Electrical Engineering ......................................................... 52
Mechanical Engineering ...................................................... 54

**Additional Resources** .................................................... 56

**Academic Year Calendar** ............................................. Inside Front Cover

**College Policy on Academic Conduct** .......................... 57
Mission Statement

The mission of the College of Engineering is to provide its students a firm grounding in scientific and mathematical fundamentals; experience in analysis, synthesis, and design of engineering systems; and exposure to current engineering practice and cutting-edge engineering research and technology. A spirit of entrepreneurship in education, scholarly activity, and participation in engineering practice infuses UCSB's College of Engineering.

College of Engineering Honors Program

The Honors Program in the College of Engineering is designed to enrich the educational opportunities of its best students. Students in the Honors Program will be encouraged to participate in early experiences in scholarship through special seminars and, in later years, as members of research teams.

Participation in the Honors Program offers housing in Scholar’s Halls located in several university-owned residence halls to eligible first-year students, as well as graduate student library privileges to all students in the program. Special lectures and tours will be offered throughout the academic year.

The College of Engineering invites approximately the top 10% of incoming freshmen into the Honors Program based on a comprehensive application review. (Please note: eligibility criteria are subject to change at any time.) Select transfer students will be invited to join the Program upon admission. Students who do not enter the College of Engineering with honors at the time of admission to UCSB may apply to join the program between first and second year after completing at least 36 letter-graded units with a cumulative GPA of 3.5 or higher, or between second and third year after completing at least 72 letter-graded units with a cumulative GPA of 3.5 or higher. Students may not join the Honors Program the summer between their junior and senior curriculum year.

To graduate as an Honors Scholar, students must complete 6.0 total Honors units during their junior and senior years; comprised of coursework from departmental 196, 197, 198, 199 courses, graduate level courses (numbered 200-299), or completing courses toward their engineering major through the UC Education Abroad Program with grades of B or higher.

Notes: Capstone participation/courses do not apply to honors credit, nor do graduate courses taken to satisfy requirements for a graduate degree. Paid research positions cannot apply. Complete a total of 10 hours of community service for each year they are program members and maintain a 3.5 or higher cumulative GPA at the end of each Spring quarter.

Continued participation in the College Honors Program is dependent on maintaining a cumulative GPA of 3.5 or greater and active participation in both the academic and community service components of the Program.

Dean's Honors

The College of Engineering gives public recognition to its outstanding undergraduate students by awarding Dean’s Honors at the end of each regular academic term to students who have earned a 3.75 grade-point average for the quarter and have completed a program of 12 or more letter-graded units. Grades of Not Passed automatically disqualify students for eligibility for Dean’s Honors. The award is noted quarterly on the student’s permanent transcript.

Graduating students of the College of Engineering who have achieved distinguished scholarship while at the university may qualify for Honors, High Honors, or Highest Honors at graduation.

Tau Beta Pi

Tau Beta Pi is the nation’s oldest and largest engineering honor society. Its purpose is to honor academic achievement in engineering. Election to membership is by invitation only. To be eligible for consideration, students must be in the top one-eighth of their junior class or the top one-fifth of the senior class. Gradu-
ate students and faculty also belong to this honor society. In addition to regular meetings on campus, the organization participates in regional and national activities and sponsors local events, such as tutoring and leadership training, to serve the campus and community.

Education Abroad Program (EAP)
Students are encouraged to broaden their academic experience by studying abroad for a year, or part of a year, under the auspices of the University of California Education Abroad Program. See the EAP web site for more information: www.eap.ucsb.edu

Student Organizations
Student chapters of a number of engineering professional organizations are active on the UCSB campus. Students interested in any of these organizations may contact the Office of Undergraduate Studies of the College of Engineering for more information.
- American Indians in Science and Engineering Society
- American Institute of Chemical Engineers
- American Society of Mechanical Engineers
- Association for Computing Machinery
- Coders SB
- Data Science at UCSB
- Engineering Student Council
- Engineers without Borders
- Entrepreneurs Association
- Institute of Electrical and Electronics Engineers
- Phi Sigma Rho
- Photonics Society at UCSB
- Robotics Club
- SB Hacks
- Society for Advancement of Chicano and Native Americans in Science
- Society of Asian Scientists and Engineers
- Society of Women Engineers
- Theta Tau
- Women in Computer Science
- Women in Science and Engineering
- Women in Software and Hardware

Change of Major and Change of College
Current UCSB students in a non-engineering major, as well as students wishing to change from one engineering major to another, are welcome to apply after the satisfactory completion of a pre-defined set of coursework. However, due to the current demand for engineering majors, students are cautioned that it is a very competitive process and not all applicants will be able to change their majors due to limited space availability. It is incumbent upon students to continue to make progress in a backup major while pursuing a new major in the College of Engineering, and to periodically consult academic advisors in both the desired major as well as the backup major regarding the viability of pursuing the change of major.

Students who enter UCSB as transfer students will not be able to change to or add an engineering major, if not initially accepted into one. Students who began as freshmen who plan to enter an engineering major or to change from one engineering major to another will be expected to complete at least 30 units at UCSB before petitioning for a change of major and usually must satisfy the prerequisites of the prospective major. Students who have completed more than 105 units will not be considered for a change of major/change of college in engineering or computer science.

Note: The College of Engineering will not accept students from the College of Creative Studies or the College of Letters and Science after they have completed 105 units, regardless of their expected unit total at graduation. Students must be at or below 105 units at the time required change of major courses are completed. Notwithstanding any of the major-specific requirements described below, we caution that the capacity of any given program to accept new students changes, sometimes substantially, from year to year.

Chemical Engineering. Admission to the Chemical Engineering major is determined by a number of factors, including each student's academic performance and trajectory, as well as current enrollments in Chemical Engineering classes. Freshman should apply during the spring term of their freshman year, and may reapply during their sophomore year. Sophomores may only apply one time during the spring term of their sophomore year. Applicants must have a 3.0 GPA or above, and satisfactorily complete the following courses or their equivalents: Math 3A, 3B, 4A; Chem 1A-1AL or 2A-2AC, 1B-1BL or 2B-2BC, and 1C-1CL or 2C-2CC. Recommended courses include: ENGR 3; Physics 1-2; ChE 5, 10, 110AB (110AB may be taken concurrently at time of application).

Computer Engineering. Students may petition to enter the Computer Engineering major at any time both of the following requirements are met:
1. An overall UCSB grade point average of at least 3.0.
2. Satisfactory completion at UCSB, with a grade point average of 3.0 or better, of any five classes, including at least two Electrical & Computer Engineering (ECE) classes and two Computer Science (CMPSC) classes, from the following: Math 4B, ECE 10A/10AL, 10B/10BL, 10C/10CL (ECE 10A/10AL, 10B/10BL, 10C/10CL each count as one course), ECE 15A, CMPSC 16, 24, 32, 40.

Acceptance into the major will be based on UC grade point averages, applicable courses completed, and space availability. All students considering changing into Computer Engineering are required to meet with the ECE Academic Advisor during their first year.

Computer Science. The application process is extremely competitive. A very limited number of change of major applications to Computer Science will be approved. Students may apply for consideration to the Computer Science major when the following requirements are met; no exceptions are made for these requirements and meeting these requirements does not guarantee admission to the Computer Science major:
1. A cumulative overall grade point average of at least 3.0;
2. Satisfactory completion of Computer Science 16, 24, and 40 with a cumulative GPA of 3.2 or higher; First takes only;
3. Satisfactory completion of Math 3A, 3B, 4A, and 4B with a cumulative GPA of 3.0 or higher; First takes only.

Denied change of major applications will not be reconsidered. More information can be found at https://cs.ucsb.edu/education/undergrad/admissions. No exceptions are made for these requirements.

Electrical Engineering. Students may petition to enter the Electrical Engineering major once both of the following requirements are met:
1. An overall UCSB grade point average of...
Degree Requirements
To be eligible for a bachelor of science degree from the College of Engineering, students must meet three sets of requirements: general university requirements, college general education requirements, and major degree requirements.

General University Requirements
All undergraduate students must satisfy university academic residency, UC Entry Level Writing Requirement, American History and Institutions, unit, and scholarship requirements. These requirements are described fully on page 10.

College General Education Requirements
All students must satisfy the general education requirements for the College of Engineering. These requirements are described on page 10 and includes a listing of courses which meet each requirement.

Major Degree Requirements
Preparation for the major and major requirements for each program must be satisfied, including unit and GPA requirements. These appear in subsequent sections of this publication.

Advanced Placement Credit
Students who complete special advanced placement courses in high school and who earn scores of 3, 4, or 5 on the College Board Advanced Placement taken before high school graduation will receive 2, 4, or 8 units of credit toward graduation at UCSB for each such test completed with the required scores, provided scores are reported to the Office of Admissions. The specific unit values assigned to each test, course equivalents, and the applicability of these credits to the General Education requirements are presented in the chart on page 8.

Note: Advanced Placement credit earned prior to entering the university will not be counted toward the minimum cumulative progress requirements (see General Catalog for more details).

International Baccalaureate Credit
Students who earn scores of 5, 6, or 7 on International Baccalaureate (IB) Higher Level (HL) Examinations taken before high school graduation will receive 8 units of credit toward graduation at UCSB for each such test completed with the required scores, provided official scores are submitted to the Office of Admissions. Students who complete the IB diploma with a score of 30 or above will receive 6 quarter units in addition to the units earned for individual Higher Level exams.

Note: International Baccalaureate Examination credit earned prior to entering the university will not be counted toward maximum unit limitation either for selection of a major or for graduation.

Minimal Progress Requirements
A student in the College of Engineering may be placed on academic probation if the total number of units passed at UCSB is fewer than what is prescribed by the prevailing academic Senate regulation regarding Minimum Cumulative Progress. At least three-fourths of the minimum number of academic units passed must include courses prescribed for the major. The following courses may be counted toward the unit minimums: courses repeated to raise C-, D, or F grades; courses passed by examination; courses graded IP (In Progress); courses passed during summer session at UCSB or at another accredited college or university and transferred to UCSB.

Students must obtain the approval of the Associate Dean for Undergraduate Studies to deviate from these requirements. Approval normally will be granted only in cases of medical disability, severe personal problems, or accidents.

Students enrolled in dual-degree programs must submit their proposed programs of study to the Associate Dean for Undergraduate Studies in the College of Engineering for approval. The individual programs must contain comparable standards of minimal academic progress.

215–Unit and Quarter Enrollment Limitations
The college expects students to graduate within 12 regular quarters for students who are admitted as freshmen and 9 regular quarters for students admitted as junior transfers and with no more than 215 units. College credit earned before high school graduation does not count toward the 215-unit maximum. This includes credit for Advanced Placement and International Baccalaureate examinations, and also college or university credit earned while still in high school.

Students who are admitted as freshmen and remain continuously enrolled will be assessed after 12 regular quarters at UCSB, and transfer students admitted as juniors will be assessed after 9 regular quarters at UCSB. Summer session does not count as a regular quarter in this calculation, but units earned in summer session do apply toward the 215-unit maximum.

With the exception of summer sessions,
if students leave UCSB and earn a large number of units at one or more other academic institutions while they are away, the number of quarters allowed at UCSB will be reduced in proportion to the number of terms completed elsewhere. College policy requires students to secure specific approval to continue enrollment beyond the quarter and unit limits noted above. Students who think they may exceed both the quarter limitations and 215 units may submit a Proposed Schedule for Graduation (Study Plan) for consideration by the Associate Dean for Undergraduate Studies, but they should understand that approval is granted in limited circumstances.

Note: The College of Engineering will not accept students from the College of Creative Studies or the College of Letters and Science after they have completed 105 units, regardless of their expected unit total at graduation.

Five-Year B.S./M.S. Degree Programs

Five-Year B.S. / M.S. in Computer Science. A combined BS/MS Program in Computer Science provides an opportunity for outstanding undergraduates to earn both degrees in five years. Additional information about this program is available from the Computer Science graduate advisor. Interested students should make their interest known to the department early in their junior year. Advising and application materials are also available in the Department of Computer Science office.

Five-Year B.S. in Computer Engineering / M.S. in Computer Science

The Computer Engineering Program incorporates the design of computer hardware and software to meet the needs for various career applications. Students are trained to work with systems ranging from small integrated circuits to worldwide communications networks, from digital watches to supercomputers, and from single-line programs to operating systems. For more information on the program, please consult the Computer Engineering department.

Five-Year B.S. in Computer Engineering or Electrical Engineering / M.S. in Electrical and Computer Engineering. A combined BS/MS Program in Computer Science provides an opportunity for outstanding undergraduates to earn both degrees in five years. Additional information about this program is available from the Electrical and Computer Engineering graduate advisor. Interested students should make their interest known to the department early in their junior year. Advising and application materials are also available in the Department of Electrical and Computer Engineering office.

**Five-Year B.S. in Chemical Engineering, Electrical Engineering, or Mechanical Engineering / M.S. in Materials**

A combined B.S. Engineering/M.S. Materials program provides an opportunity for outstanding undergraduates in chemical, electrical, or mechanical engineering to earn both of these degrees in five years. This program enables students to develop all of the requisite knowledge in their core engineering disciplines and to complement this with a solid background in materials. This combination provides highly desirable training from an industrial employment perspective and capitalizes on the strengths of our internationally renowned materials department.

There is a five-year option for students who are pursuing a B.S. in Chemistry in the College of Letters and Science to complete an M.S. degree in Materials. Interested students should contact the Undergraduate Advisor in the Department of Chemistry & Biochemistry for additional information.

**Five-Year B.S. / M.S. in Mechanical Engineering.** A combined B.S./M.S. program in Mechanical Engineering provides an opportunity for outstanding undergraduates to earn both degrees in five years. Additional information about this program is available from the Mechanical Engineering Undergrad Advising office. Interested students should contact the office fall quarter of their junior year. In addition to fulfilling undergraduate degree requirements, B.S./M.S. degree candidates must meet Graduate Division degree requirements, including university requirements for academic residence and units of coursework.
International Baccalaureate Higher Level Examinations

Students who earn scores of 5, 6, or 7 on International Baccalaureate (IB) Higher Level (HL) Examinations taken before high school graduation will receive 8 units of credit toward graduation at UCSB for each such test completed with the required scores, provided official scores are submitted to the Office of Admissions. Students who complete the IB diploma with a score of 30 or above will receive 6 quarter units in addition to the units earned for individual Higher Level exams. The university does not grant credit for Standard Level (SL) exams. The application of this credit to the General Education requirements and course equivalents for these exams are listed below.

Students should be advised that college courses taken before or after attending UC may duplicate AP, IB and/or A Level examinations. Additionally, exams may duplicate each other (for example, an AP or IB exam in the same subject area). If the student does duplicate an exam with another exam of the same subject content, and/or an exam with a college course, we will award credit only once.

Note: International Baccalaureate credit earned prior to entering the university will not be counted toward maximum unit limitations either for selection of a major or for graduation.

INTERNATIONAL BACCALAUREATE INFORMATION

<table>
<thead>
<tr>
<th>Exam with score of 5, 6, Or 7</th>
<th>Units</th>
<th>COE GE Credit</th>
<th>UCSB Equivalent Course(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biology</td>
<td>8</td>
<td>none</td>
<td>EEMB 22, MCDB 20</td>
</tr>
<tr>
<td>Business Management</td>
<td>8</td>
<td>none</td>
<td>none</td>
</tr>
<tr>
<td>Chemistry</td>
<td>8</td>
<td>none</td>
<td>none</td>
</tr>
<tr>
<td>Computer Science</td>
<td>8</td>
<td>none</td>
<td>Computer Science 8</td>
</tr>
<tr>
<td>Dance</td>
<td>8</td>
<td>none</td>
<td>none</td>
</tr>
<tr>
<td>Economics</td>
<td>8</td>
<td>D: 2 courses</td>
<td>Economics 1, 2</td>
</tr>
<tr>
<td>English A: Literature or</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>English A: Language And Literature</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Score Of 5</td>
<td>8</td>
<td>Entry Level Writing</td>
<td>Writing 1, 1E</td>
</tr>
<tr>
<td>Score Of 6</td>
<td>8</td>
<td>A1</td>
<td>Writing 1, 1E, 2, 2E, 2LK</td>
</tr>
<tr>
<td>Score Of 7</td>
<td>8</td>
<td>A1, A2,</td>
<td>Writing 1, 1E, 2, 2E, 2LK, 50, 50E</td>
</tr>
<tr>
<td>English B</td>
<td>8</td>
<td>none</td>
<td>none</td>
</tr>
<tr>
<td>Film</td>
<td>8</td>
<td>none</td>
<td>none</td>
</tr>
<tr>
<td>Geography</td>
<td>8</td>
<td>D: 1 course</td>
<td>none</td>
</tr>
<tr>
<td>Global Politics</td>
<td>8</td>
<td>D: 1 course</td>
<td>none</td>
</tr>
<tr>
<td>History</td>
<td>8</td>
<td>E: 1 course^</td>
<td>none</td>
</tr>
<tr>
<td>History of Africa</td>
<td>8</td>
<td>D: 1 course+</td>
<td>none</td>
</tr>
<tr>
<td>History of the Americas</td>
<td>8</td>
<td>D: 1 course</td>
<td>none</td>
</tr>
<tr>
<td>History of Asia And Oceania</td>
<td>8</td>
<td>D: 1 course</td>
<td>none</td>
</tr>
<tr>
<td>History of Europe and the Middle East</td>
<td>8</td>
<td>D: 1 course^</td>
<td>none</td>
</tr>
<tr>
<td>Languages Other Than English</td>
<td>8</td>
<td>none</td>
<td>See department for level placement</td>
</tr>
<tr>
<td>Mathematics%</td>
<td>8</td>
<td>none</td>
<td>Mathematics 2A, 2B, 3A, 3B, 34A, 34B, or equivalent</td>
</tr>
<tr>
<td>Mathematics, Further%</td>
<td>8</td>
<td>none</td>
<td>none</td>
</tr>
<tr>
<td>Mathematics, Analysis &amp; Approaches</td>
<td>8</td>
<td>none</td>
<td>Mathematics 2A, 3A</td>
</tr>
<tr>
<td>Music</td>
<td>8</td>
<td>F: 1 course</td>
<td>none</td>
</tr>
<tr>
<td>Philosophy</td>
<td>8</td>
<td>E: 1 course</td>
<td>none</td>
</tr>
<tr>
<td>Physics</td>
<td>8</td>
<td>none</td>
<td>Physics 10</td>
</tr>
<tr>
<td>Social &amp; Cultural Anthropology</td>
<td>8</td>
<td>D: 1 course</td>
<td>Anthropology 2</td>
</tr>
<tr>
<td>Theater</td>
<td>8</td>
<td>F: 1 course</td>
<td>none</td>
</tr>
<tr>
<td>Visual Arts</td>
<td>8</td>
<td>F: 1 course</td>
<td>none</td>
</tr>
<tr>
<td>Psychology</td>
<td>8</td>
<td>D: 1 course</td>
<td>none</td>
</tr>
</tbody>
</table>

\^ Course also satisfies the european traditions requirement
\+ Course also satisfies the world cultures requirement
\% Last Offered Fall 2020
College Board Advanced Placement Credit

Students who earn scores of 3, 4, or 5 on College Board Advanced Placement Examinations taken before high school graduation will receive 2, 4, or 8 units of credit toward graduation at UCSB for each such test completed with the required scores, provided official scores are submitted to the Office of Admissions.

Students should be advised that college courses taken before or after attending UC may duplicate AP, IB and/or A Level examinations. Additionally, exams may duplicate each other (for example, AP or IB exam in the same subject area). If the student does duplicate an exam with another exam of the same subject content, and/or an exam with a college course, we will award credit only once.

Note: Advanced Placement credit earned prior to entering the university will not be counted toward maximum unit limitations either for selection of a major or for graduation.

<table>
<thead>
<tr>
<th>Advanced Placement Exam with score of 3, 4, or 5</th>
<th>Units Awarded</th>
<th>General Ed. Course Credit</th>
<th>UCSB Course Equivalent (You may not enroll in these courses for credit at UCSB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2D Art and Design</td>
<td>8</td>
<td>none</td>
<td>none</td>
</tr>
<tr>
<td>3D Art and Design</td>
<td>8</td>
<td>none</td>
<td>none</td>
</tr>
<tr>
<td>Art History</td>
<td>8</td>
<td>F: 1 course</td>
<td>Art History 1</td>
</tr>
<tr>
<td>Biology</td>
<td>8</td>
<td>none</td>
<td>EEMB 22, MCDB 20</td>
</tr>
<tr>
<td>Chemistry</td>
<td>8</td>
<td>none</td>
<td>none</td>
</tr>
<tr>
<td>Chinese Language and Culture With score of 3</td>
<td>8</td>
<td>none</td>
<td>See department for level placement</td>
</tr>
<tr>
<td>Comparative Government and Politics</td>
<td>4</td>
<td>D: 1 course</td>
<td>none</td>
</tr>
<tr>
<td>+Computer Science A (through S17) With score of 3</td>
<td>2 or 8+</td>
<td>none</td>
<td>Computer Science 8</td>
</tr>
<tr>
<td>+Computer Science A (through S17) With score of 4</td>
<td>8</td>
<td>none</td>
<td>Computer Science 8</td>
</tr>
<tr>
<td>+Computer Science A (through S17) With score of 5</td>
<td>8</td>
<td>none</td>
<td>Computer Science 8</td>
</tr>
<tr>
<td>Computer Science Principles (effective S17 and S18) With score of 3</td>
<td>8</td>
<td>none</td>
<td>Computer Science 8</td>
</tr>
<tr>
<td>Computer Science Principles (effective S19) With score of 3</td>
<td>8</td>
<td>none</td>
<td>Computer Science 4</td>
</tr>
<tr>
<td>Computer Science Principles (effective S19) With score of 4 or 5</td>
<td>8</td>
<td>none</td>
<td>Art 18</td>
</tr>
<tr>
<td>Drawing</td>
<td>8</td>
<td>none</td>
<td>none</td>
</tr>
<tr>
<td>Macroeconomics</td>
<td>4</td>
<td>D: 1 course</td>
<td>none</td>
</tr>
<tr>
<td>Microeconomics</td>
<td>4</td>
<td>D: 1 course</td>
<td>none</td>
</tr>
<tr>
<td>*English – Composition and Literature or Language and Composition With score of 3</td>
<td>8</td>
<td>Entry Level Writing</td>
<td>Writing 1, 1E</td>
</tr>
<tr>
<td>*English – Composition and Literature or Language and Composition With score of 4</td>
<td>8</td>
<td>A1</td>
<td>Writing 1, 1E, 2, 2E, 2LK</td>
</tr>
<tr>
<td>*English – Composition and Literature or Language and Composition With score of 5</td>
<td>8</td>
<td>A1, A2</td>
<td>Writing 1, 1E, 2, 2E, 2LK, 50, 50E</td>
</tr>
<tr>
<td>Environmental Science</td>
<td>4</td>
<td>none</td>
<td>Environmental Studies 2</td>
</tr>
<tr>
<td>European History</td>
<td>8</td>
<td>E: 1 course</td>
<td>none</td>
</tr>
<tr>
<td>French Language and Culture With score of 3</td>
<td>8</td>
<td>none</td>
<td>French 1-3</td>
</tr>
<tr>
<td>French Language and Culture With score of 4</td>
<td>8</td>
<td>none</td>
<td>French 1-4</td>
</tr>
<tr>
<td>French Language and Culture With score of 5</td>
<td>8</td>
<td>none</td>
<td>French 1-5</td>
</tr>
<tr>
<td>German Language and Culture With score of 3</td>
<td>8</td>
<td>none</td>
<td>German 1-3</td>
</tr>
<tr>
<td>German Language and Culture With score of 4</td>
<td>8</td>
<td>none</td>
<td>German 1-4</td>
</tr>
<tr>
<td>German Language and Culture With score of 5</td>
<td>8</td>
<td>none</td>
<td>German 1-5</td>
</tr>
<tr>
<td>Human Geography</td>
<td>4</td>
<td>D: 1 course</td>
<td>Geography 5</td>
</tr>
<tr>
<td>Italian Language and Culture With score of 3</td>
<td>8</td>
<td>none</td>
<td>Italian 1-3</td>
</tr>
<tr>
<td>Italian Language and Culture With score of 4</td>
<td>8</td>
<td>none</td>
<td>Italian 1-5</td>
</tr>
<tr>
<td>Italian Language and Culture With score of 5</td>
<td>8</td>
<td>none</td>
<td>Italian 1-6</td>
</tr>
<tr>
<td>Japanese Language &amp; Culture With score of 3</td>
<td>8</td>
<td>none</td>
<td>See department for level placement</td>
</tr>
<tr>
<td>Japanese Language &amp; Culture With score of 4</td>
<td>8</td>
<td>none</td>
<td>See department for level placement</td>
</tr>
<tr>
<td>Japanese Language &amp; Culture With score of 5</td>
<td>8</td>
<td>none</td>
<td>See department for level placement</td>
</tr>
<tr>
<td>Latin</td>
<td>8</td>
<td>none</td>
<td>Latin 1-3</td>
</tr>
<tr>
<td>*Calculus AB (or AB subscore of BC exam)</td>
<td>4</td>
<td>none</td>
<td>Mathematics 2A, 3A, 34A, or equivalent</td>
</tr>
<tr>
<td>*Calculus BC</td>
<td>8</td>
<td>none</td>
<td>Mathematics 2A, 2B, 3A, 3B, 34A, 34B, or equivalent</td>
</tr>
<tr>
<td>Music Theory</td>
<td>8</td>
<td>F: 1 course</td>
<td>Music 11</td>
</tr>
<tr>
<td>*Physics 1 (effective S’15)</td>
<td>8</td>
<td>none</td>
<td>none</td>
</tr>
<tr>
<td>*Physics 2 (effective S’15)</td>
<td>8</td>
<td>none</td>
<td>none</td>
</tr>
<tr>
<td>*Physics – B (last offered S’14)</td>
<td>8</td>
<td>none</td>
<td>Physics 10</td>
</tr>
<tr>
<td>*Physics – C (Mechanics)</td>
<td>4</td>
<td>none</td>
<td>Physics 6A and 6AL</td>
</tr>
<tr>
<td>*Physics – C (Electricity and Magnetism)</td>
<td>4</td>
<td>none</td>
<td>Physics 6B and 6BL</td>
</tr>
<tr>
<td>Psychology</td>
<td>4</td>
<td>D: 1 course</td>
<td>Psychology 1</td>
</tr>
<tr>
<td>Spanish Language and Culture With score of 3</td>
<td>8</td>
<td>none</td>
<td>Spanish 1-3</td>
</tr>
<tr>
<td>Spanish Language and Culture With score of 4</td>
<td>8</td>
<td>none</td>
<td>Spanish 1-4</td>
</tr>
<tr>
<td>Spanish Language and Culture With score of 5</td>
<td>8</td>
<td>none</td>
<td>Spanish 1-5</td>
</tr>
</tbody>
</table>
A Level Examination Credit

Students who earn grades of A, B, or C on UC-approved GCE and Hong Kong A Level examinations will receive 12 units of credit toward graduation at UCSB for each exam, provided that official grades are submitted to the Office of Admissions. Any general education credit or UCSB course equivalents listed in the chart below will be awarded only for Cambridge International A Level exams taken in 2013 or later, not for exams administered by any other agency. (Student may petition for GE or course credit for Cambridge International exams taken prior to 2013 or for exams administered by other agencies.)

Students should be advised that college courses taken before or after attending UC may duplicate AP, IB and/or A Level examinations. Additionally, exams may duplicate each other (for example, an AP or IB exam in the same subject area). If the student does duplicate an exam with another exam of the same subject content, and/or an exam with a college course, we will award credit only once.

Note: A Level examination credit earned prior to entering the university will not be counted toward maximum unit limitation either for selection of a major or for graduation.

<table>
<thead>
<tr>
<th>Advanced Placement Exam with score of 3, 4, or 5</th>
<th>Units Awarded</th>
<th>General Ed. Course Credit</th>
<th>UCSB Course Equivalent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spanish Literature and Culture</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>With score of 3</td>
<td>8</td>
<td>none</td>
<td>Spanish 1-4</td>
</tr>
<tr>
<td>With score of 4</td>
<td>8</td>
<td>none</td>
<td>Spanish 1-5</td>
</tr>
<tr>
<td>With score of 5</td>
<td>8</td>
<td>none</td>
<td>Spanish 1-6</td>
</tr>
<tr>
<td>Statistics</td>
<td>4</td>
<td>none</td>
<td>Communication 87, PSTAT SAA-ZZ, Psychology 5</td>
</tr>
<tr>
<td>United States Government and Politics</td>
<td>4</td>
<td>D: 1 course</td>
<td>Political Science 12</td>
</tr>
<tr>
<td>United States History</td>
<td>8</td>
<td>E: 1 course</td>
<td>none</td>
</tr>
<tr>
<td>World History: Modern</td>
<td>8</td>
<td>E: 1 course</td>
<td>none</td>
</tr>
</tbody>
</table>

* A maximum of 8 units EACH in art studio, English, Mathematics, and Physics is allowed.
+ 8 units effective Spring 2018. Computer Science A exam is 2 units through Spring 2017.

Note: Information on this chart is subject to change. For updates go to: http://my.sa.ucsb.edu/catalog/current/UndergraduateEducation/APCreditandChart.aspx.
General University Requirements

UC Entry Level Writing Requirement

All students entering the University of California must demonstrate an ability to write effectively by fulfilling the Entry Level Writing requirement. The requirement may be met in one of the following ways prior to admission:

1. by achieving a score of 680 or higher on the Writing section of the SAT Reasoning Test;
2. by achieving a score of 30 or higher on the ACT Combined English Language Arts (ELA) test;
3. by achieving a score of 3 or higher on the College Board Advanced Placement Examination in English Composition and Literature or English Language and Composition;
4. by achieving a score of 5, 6, or 7 on the higher level English A1 International Baccalaureate Examination;
5. by achieving a score of 6 or 7 on the standard level English A1 International Baccalaureate Examination;
6. by passing the University of California systemwide Analytical Writing Placement Exam while in high school;
7. by earning a grade of C or higher in a course accepted as equivalent to Writing 2 worth 4 quarter or 3 semester units.

Students who have not met the UC Entry Level Writing Requirement in one of the ways listed above will be required to take a placement exam.

Students who do not achieve an appropriate score on the placement exam to fulfill the Entry Level Writing Requirement must enroll in Writing 1, 1E, or Linguistics 12 within their first year at UCSB. Visit the Writing Program’s website (writing.ucsb.edu/academics) for placement exam information.

American History and Institutions Requirement

The American History and Institutions requirement is based on the principle that American students enrolled at an American university should have some knowledge of the history and government of their country. You may meet this requirement in any one of the following ways:

1. by achieving a score of 3 or higher on the College Board Advanced Placement Examination in American History or American Government and Politics; or
2. by passing a non-credit examination in American history or American institutions, offered in the Department of History during the first week of each quarter. Consult the department for further information; or
3. by achieving a score of 650 or higher on SAT II: Subject Test in American History; or
4. by completing one four-unit course from the following list of courses:
   - Anthropology 131
   - Art History 121A-B-C-E, 136H
   - Asian American Studies 1, 2
   - Black Studies 1, 6, 20, 60A-B, 103, 137E, 169AR-BR-CR
   - Chicano Studies 1A-B-C, 168B, 174, 188C
   - Economics 131A-B, 119
   - English 133AA-ZZ, 134AA-ZZ, 191
   - Environmental Studies 173
   - Feminist Studies 155A, 159B
   - Military Science 27
   - Political Science 12, 115, 127, 151, 153, 155, 157, 158, 162, 165, 167, 180, 185
   - Religious Studies 7, 14, 61A-B, 151A-B, 152
   - Sociology 137E, 140, 144, 155A, Theater 180A-B

Courses used to fulfill the American History and Institutions requirement may also be applied to General Education or major requirements, or both where appropriate. Equivalent courses taken at other accredited colleges or universities, in UC Extension, or in summer session may be acceptable. Students who transfer to UCSB from another campus of the University of California where the American History and Institutions Requirement has been considered satisfied will automatically fulfill the requirement at UCSB.

International students on a nonimmigrant visa may petition for a waiver of this requirement through the Office of International Students and Scholars.

College of Engineering General Education Requirements

The aims of the General Education Program in the College of Engineering are to provide a body of knowledge of general intellectual value that will give the student a broad cultural base and to meet the objectives of the engineering profession. An appreciation and understanding of the humanities and social sciences are important in making engineers aware of their social responsibilities and enabling them to consider related factors in the decision-making process.

Students in the College of Engineering must complete the General Education requirements in order to qualify for graduation. Students are reminded that other degree requirements exist and that they are responsible for familiarizing themselves with all bachelor’s degree requirements. Not all of the courses listed in this publication are offered every quarter. Please see the GOLD system for General Education courses offered during a particular quarter.

It should be noted that for College of Engineering transfers who completed IGETC (Intersegmental General Education Transfer Curriculum), it may be used to substitute for entire UCSB College of Engineering General Education pattern (IGETC does not satisfy the American History and Institutions requirement).

Students who have questions about the General Education requirements should consult with the advisors in College of Engineering Office of Undergraduate Studies.

GENERAL SUBJECT AREA REQUIREMENTS

A total of 8 courses is required to satisfy the General Education requirements of the College of Engineering. All students must follow the pattern of distribution shown below:

I. Area A: English Reading and Composition


Chemical Engineering, Computer Engineering, Electrical Engineering, and Mechanical Engineering majors
are strongly encouraged to take Writing 2E and 50E in their first year at UCSB. Computer Science majors may take Writing 2E and 50E space permitting.

NOTE: Students must complete the UC Entry Level Writing Requirement before enrolling in courses that fulfill the Area A requirement of the General Education program. Please refer to page 10 of this publication or the UCSB General Catalog for a list of ways to satisfy the UC Entry Level Writing requirement.

II. Areas D, E, F, & G: Social Sciences, Culture and Thought, the Arts, and Literature

At least 6 courses must be completed in these areas:
Area D: A minimum of 2 courses must be completed in Area D.
Area E: A minimum of 2 courses must be completed in Area E.
Area F: A minimum of 1 course must be completed in Area F.
Area G: A minimum of 1 course must be completed in Area G.
The general provisions relating to General Education requirements, as listed on page 12, must be followed when completing courses in Areas D, E, F, and G.
A complete listing of courses, which will satisfy all these requirements starts on page 13.

SPECIAL SUBJECT AREA REQUIREMENTS

In the process of fulfilling the General Education General Subject Areas D through G requirements, students must complete the following Special Subject Area requirements:

1. Writing Requirement. Objective: To study and practice with writing, reading, and critical analysis within specific disciplines. Students will demonstrate abilities by producing written work totaling at least 1,800 words that is independent of or in addition to written examinations; and (3) the paper(s) is a significant consideration in the assessment of student performance in the course. Courses marked with an asterisk (*) on the lists in this document apply to this requirement. The writing requirement may be met only with designated UCSB courses approved by the Academic Senate.

NOTES: ENGR 101 may be used as a writing requirement class, even by those students for whom ENGR 101 is required.
New transfer students should consult with the College Undergraduate Studies Office regarding this requirement.

2. Ethnicity Requirement. Objective: To learn to identify and understand the philosophical, intellectual, historical, and/or cultural experiences of historically oppressed and excluded racial minorities in the United States. At least one course in this area is required. Courses that meet this requirement are marked with an ampersand (&) on the lists in this document.

3. European Traditions or World Cultures Requirement.

European Traditions Objective: To learn to analyze early and/or modern European cultures and their significance in world affairs. Courses that meet this requirement are marked with a caret (^) on the lists in this document.

World Cultures objective: To learn to identify, understand, and appreciate the history, thought, and practices of one or more cultures outside of the European Tradition. Courses that meet this requirement are marked with a plus sign (+) on the lists in this document.

At least one course from either of these areas (European Traditions or World Cultures) is required.

Other Regulations:

- A course listed in more than one general subject area can be applied to only one of these areas. (Example: Art History 6A cannot be applied to both Areas E and F.) However, a course can be applied towards a single general subject area and any special subject areas which that course fulfills.
- Some courses taken to satisfy the General Education requirements may also be applied simultaneously to the American History and Institutions requirement. Such courses must be on the list of approved General Education courses and on the list of approved American History and Institutions courses.
- Courses taken to fulfill a General Education requirement may be taken on a P/NP basis, if the course is offered with that grading option (refer to GOLD for the grading option for a particular course).
GENERAL EDUCATION COURSES

NOTE: The course listing in this booklet reflects the courses accepted for use towards the General Education requirements at the time of this document's publication and is subject to change. Please refer to GOLD for a listing of acceptable courses during the given quarter. Information in GOLD supersedes the information given here. Only Academic Senate approved courses can apply to GE.

AREA A: ENGLISH READING AND COMPOSITION (2 courses required)
Objective: To learn to analyze purposes, audiences, and contexts for writing through study of and practice with writing.

Writing 2 or 2E and one course from the following list:
Writing 50 Writing and the Research Process
Writing 50E Writing and the Research Process for Engineers
Writing 105CD Writing with Code
Writing 105CW Writing in Community
Writing 105M Multimedia Writing
Writing 105PD Writing and Public Discourse
Writing 105PS Writing for Public Speaking
Writing 105S Writing about Sustainability
Writing 105SW Science Writing for the Public
Writing 107B Business and Administrative Writing
Writing 107EP Writing for Environmental Professions
Writing 107GS Professional Writing for Global Careers
Writing 107J Journalism and News Writing
Writing 107L Legal Writing
Writing 107M Magazine Writing for Publication
Writing 107T Technical Writing
Writing 107WC Writing for Web Content
Writing 109ED Writing for the Teaching Professions
Writing 109ES Writing for Environmental Studies
Writing 109HP Writing for Health Professions
Writing 109ST Writing for Science and Technology

AREA D: SOCIAL SCIENCES (2 courses minimum)
Objective: To apply perspectives, theories, and methods of social science research to understand what motivates, influences, and/or determines the behaviors of individuals, groups, and societies. Area D courses are based upon systematic studies of human behavior which may include observation, experimentation, deductive reasoning, and quantitative analysis.

+ Anthropology 2
+ Anthropology 3
+ Anthropology 35
+ Anthropology 75
+ Anthropology 103
+ Anthropology 109
+ Anthropology 110
+ Anthropology 122
+ Anthropology 130
+ Anthropology 138
+ Anthropology 131
+ Anthropology 134
+ Anthropology 138
+ Anthropology 137
+ Anthropology 141

* Anthropology 25
+ Anthropology 103A
+ Anthropology 103B
+ Anthropology 103C
+ Anthropology 109
+ Anthropology 110
+ Anthropology 122
+ Anthropology 130A
+ Anthropology 130B
+ Anthropology 131
+ Anthropology 134
+ Anthropology 135
+ Anthropology 136
+ Anthropology 137
+ Anthropology 141

Introduction to BioSocial Anthropology
Introduction to Archaeology
Violence and the Japanese State
Anthropology of China
Anthropology of Japan
Anthropology of Korea
Human Universals
Technology and Culture
Anthropology of World Systems
Coupled Human and Natural Systems: Risks, Vulnerability, Resilience, and Disasters
Global Tourism and Environmental Conservation
North American Indians
Modern Cultures of Latin America
Modern Mexican Culture
Peoples and Cultures of the Pacific
The Ancient Maya
Agriculture and Society in Mexico: Past and Present

Peoples and Cultures of India
Understanding Africa
Representations of Sexuality in Modern Japan (Same as HIST 188S and JAPAN 162)
Indigenous Movements in Asia
Introduction to Asian American History, 1850-Present
American Migration since 1965
Asian American Globalization
Introduction to Asian American Gender and Sexuality
Asian American Freedom Struggles and Third World Resistance
Chinese Americans
Japanese Americans
South Asian Americans
Asian American Communities and Contemporary Issues
Asian Americans and Race Relations
Colonialism and Migration in the Passage to America
Asian American Women's History
Asian American Families
Race and Law in Early American History
Racial Segregation from the Civil War to the Civil Rights Movement
Race and Law in Modern America
Asian Americans and Education
Ethnographies of Asian Americans
Introduction to Afro-American Studies
Critical Introduction to Race and Racism
Africa and United States Policy
Black Radicals and the Radical Tradition
The Politics of Black Liberation-The Sixties
The Education of Black Children
Housing, Inheritance and Race
Queer Black Studies
The Urban Dilemma
Race and Public Policy
Analyses of Racism and Social Policy in the U.S.

* This course applies toward the Writing requirement.
& This course applies toward the Ethnicity requirement.
+ This course applies toward the World Cultures requirement.
® This course applies toward the American History & Institutions requirement.
^ This course applies toward the European Traditions requirement.
This course applies toward the Writing requirement.
+ This course applies toward the World Cultures requirement.
& This course applies toward the Ethnicity requirement.
^ This course applies toward the European Traditions requirement.
* This course applies toward the American History & Institutions requirement.
@ This course applies toward the American History & Institutions requirement.

**AREA E: CULTURE AND THOUGHT (2 courses minimum)**

Objective: To learn to situate and investigate questions about world cultures through the study of human history and thought and to learn about the roles that citizens play in the construction and negotiation of human history and cultures.

<table>
<thead>
<tr>
<th>Course</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Anthropology</strong></td>
<td><strong>Language and Linguistics</strong></td>
</tr>
<tr>
<td><strong>Languages</strong></td>
<td><strong>American-English</strong></td>
</tr>
<tr>
<td><strong>History</strong></td>
<td><strong>Language in Society</strong></td>
</tr>
<tr>
<td><strong>Languages</strong></td>
<td><strong>Language in Society</strong></td>
</tr>
<tr>
<td><strong>History</strong></td>
<td><strong>Language as Culture</strong></td>
</tr>
<tr>
<td><strong>Languages</strong></td>
<td><strong>Language, Gender, and Sexuality</strong></td>
</tr>
<tr>
<td><strong>History</strong></td>
<td><strong>Language as Culture</strong></td>
</tr>
<tr>
<td><strong>Languages</strong></td>
<td><strong>Language in Social Interaction</strong></td>
</tr>
<tr>
<td><strong>History</strong></td>
<td><strong>Language in American Ethnic Minorities</strong></td>
</tr>
<tr>
<td><strong>Languages</strong></td>
<td><strong>Language, Power, and Learning</strong></td>
</tr>
<tr>
<td><strong>Military Science</strong></td>
<td><strong>American Military History and the Evolution of Western Warfare</strong></td>
</tr>
<tr>
<td><strong>Music</strong></td>
<td><strong>Music Cultures of the World: China</strong></td>
</tr>
<tr>
<td><strong>Music</strong></td>
<td><strong>Music Cultures of the World: Mide East</strong></td>
</tr>
<tr>
<td><strong>Music</strong></td>
<td><strong>Music Cultures of the World: India</strong></td>
</tr>
<tr>
<td><strong>Music</strong></td>
<td><strong>Music Cultures of the World: Indonesia</strong></td>
</tr>
<tr>
<td><strong>Political Science</strong></td>
<td><strong>American Government and Politics</strong></td>
</tr>
<tr>
<td><strong>Political Science</strong></td>
<td><strong>Courts, Judges and Politics</strong></td>
</tr>
<tr>
<td><strong>Political Science</strong></td>
<td><strong>International Politics</strong></td>
</tr>
<tr>
<td><strong>Political Science</strong></td>
<td><strong>The European Union</strong></td>
</tr>
<tr>
<td><strong>Political Science</strong></td>
<td><strong>Politics of the Middle East</strong></td>
</tr>
<tr>
<td><strong>Political Science</strong></td>
<td><strong>Voting and Elections</strong></td>
</tr>
<tr>
<td><strong>Political Science</strong></td>
<td><strong>Congress</strong></td>
</tr>
<tr>
<td><strong>Psychology</strong></td>
<td><strong>Introduction to Psychology</strong></td>
</tr>
<tr>
<td><strong>Psychology</strong></td>
<td><strong>Health Psychology</strong></td>
</tr>
<tr>
<td><strong>Psychology</strong></td>
<td><strong>Introduction to Social Psychology</strong></td>
</tr>
<tr>
<td><strong>Psychology</strong></td>
<td><strong>Introduction to Psychopathology</strong></td>
</tr>
<tr>
<td><strong>Psychology</strong></td>
<td><strong>Developmental Psychology</strong></td>
</tr>
<tr>
<td><strong>Religious Studies</strong></td>
<td><strong>Introduction to American Religion</strong></td>
</tr>
<tr>
<td><strong>Religious Studies</strong></td>
<td><strong>Introduction to Native American Religious Studies</strong></td>
</tr>
<tr>
<td><strong>Religious Studies</strong></td>
<td><strong>Religion and Psychology</strong></td>
</tr>
<tr>
<td><strong>Religious Studies</strong></td>
<td><strong>Introduction to Religion and Politics</strong></td>
</tr>
<tr>
<td><strong>Religious Studies</strong></td>
<td><strong>Literature and Religion of the Hebrew Bible Old Testament</strong></td>
</tr>
<tr>
<td><strong>Religious Studies</strong></td>
<td><strong>Politics and Religion in the City: Jerusalem</strong></td>
</tr>
<tr>
<td><strong>Religious Studies</strong></td>
<td><strong>Sociology of Religion: The Classical Statements</strong></td>
</tr>
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<td><strong>Religion and the American Experience</strong></td>
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<tr>
<td><strong>Religious Studies</strong></td>
<td><strong>Religion in American History</strong></td>
</tr>
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<td><strong>Religious Studies</strong></td>
<td><strong>Religion in America Today</strong></td>
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<td><strong>Anthropology of Religion</strong></td>
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<td><strong>Religious Studies</strong></td>
<td><strong>Language and Cultural Identity</strong></td>
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<td><strong>Religious Studies</strong></td>
<td><strong>Ideology and Representation</strong></td>
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<td><strong>Religious Studies</strong></td>
<td><strong>Introduction to Sociology</strong></td>
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<td><strong>Political Sociology</strong></td>
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<td><strong>Religious Studies</strong></td>
<td><strong>Social Movements</strong></td>
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<td><strong>The Chicano Community (Same as CH ST 144)</strong></td>
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<td><strong>Religious Studies</strong></td>
<td><strong>Sociology 134</strong></td>
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<td><strong>Religious Studies</strong></td>
<td><strong>Sociology of Human Sexuality</strong></td>
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<td><strong>Sociology 152A</strong></td>
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<td><strong>Religious Studies</strong></td>
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<td><strong>Spanish 178</strong></td>
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<td><strong>Religious Studies</strong></td>
<td><strong>Mexican Culture</strong></td>
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<td><strong>Anthropology 138TS</strong></td>
<td><strong>Archaeology of Egypt</strong></td>
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<td><strong>Representations of Sexuality in Modern Japan</strong></td>
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<td><strong>Same as HIST 186S and JAPAN 162</strong></td>
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<td><strong>Anthropology 176TS</strong></td>
<td><strong>Ancient Egyptian Religion</strong></td>
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<td><strong>Art History 6A-B-C</strong></td>
<td><strong>Art Survey</strong></td>
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<td><strong>Art History 6L</strong></td>
<td><strong>History of Games</strong></td>
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<td><strong>Art History 6R</strong></td>
<td><strong>Rome: The Game</strong></td>
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<td><strong>Art History 115E</strong></td>
<td><strong>The Grand Tour: Experiencing Italy in the Eighteenth Century</strong></td>
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<td><strong>Art History 136I</strong></td>
<td><strong>The City in History</strong></td>
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<td><strong>Art History 144D</strong></td>
<td><strong>Russian Art</strong></td>
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<td><strong>Art History 148A</strong></td>
<td><strong>Contemporary Art History: 1960-2000</strong></td>
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+ This course applies toward the Writing requirement.
& This course applies toward the Ethnicity requirement.
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^ This course applies toward the European Traditions requirement.
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<tr>
<th>Number</th>
<th>Course Title</th>
<th>Description</th>
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<tbody>
<tr>
<td>&amp; Art History 148B</td>
<td>Global Art After 1980</td>
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<td>&amp; Asian American Studies 71</td>
<td>Introduction to Asian American Religions</td>
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<td>&amp; Asian American Studies 138</td>
<td>Asian American Sexualities</td>
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<td>&amp; Asian American Studies 161</td>
<td>Asian American Religions (Same as RG ST 123)</td>
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<td>+ Black Studies 3</td>
<td>Introduction to African Studies</td>
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<td>* Black Studies 5</td>
<td>Blacks and Western Civilization</td>
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<td>* Black Studies 49A-B</td>
<td>Survey of African History</td>
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<td>&amp; Black Studies 50</td>
<td>Blacks in the Media</td>
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<td>+ Black Studies 104</td>
<td>Black Marxism</td>
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<td>* Black Studies 130A</td>
<td>Negritude and African Literature</td>
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<td>+ Black Studies 130B</td>
<td>The Black Francophone Novel</td>
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<td>+ Chicano Studies 113</td>
<td>Critical Introduction to Ancient Mesoamerica</td>
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<td>+ Chinese 26</td>
<td>New Phenomena in 21st Century Chinese</td>
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<td>+ Chinese 32</td>
<td>Contemporary Chinese Religions</td>
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<td>+ Chinese 148</td>
<td>Historic Lives</td>
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<tr>
<td>+ Chinese 183B</td>
<td>Reap Practice and the State in China</td>
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<td>* Chinese 185A</td>
<td>Qing Empire</td>
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<td>* Chinese 185B</td>
<td>Modern China (since 1911)</td>
<td></td>
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<tr>
<td>^ Classics 20B</td>
<td>The Romans</td>
<td></td>
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<td>^ Classics 50</td>
<td>Introduction to Classical Archaeology</td>
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<td>^ Classics 101</td>
<td>The Greek Intellectual Experience: From Poetry to Philosophy</td>
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<tr>
<td>* Classics 106</td>
<td>Magic and Medicine in Ancient Greece</td>
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<td>^ Classics 140</td>
<td>Slavery and Freedom in the Ancient World</td>
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<td>^ Classics 150</td>
<td>The Fall of the Ancient Republic: Cicero, Caesar, and Rome</td>
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<td>Classics 151</td>
<td>Emperors and Gladiators: History of the Roman Empire to 180CE</td>
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<td>^ Classics 152</td>
<td>Citizenship: Ancient Origins and Modern Practices</td>
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<td>^ Classics 171</td>
<td>Artfact and Text: The Archaeology and Literature of Early Greece</td>
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<td>Comparative Literature 27</td>
<td>Memory: Bridging the Humanities and Neurosciences (Same as FR 40X &amp; MCDB27)</td>
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<td>^ Comparative Literature 35</td>
<td>The Making of the Modern World</td>
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<td>^ Comparative Literature 113</td>
<td>Trauma, Memory, Historiography</td>
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<td>^ Comparative Literature 119</td>
<td>Psychoanalytic Theory</td>
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<td>^ Comparative Literature 122A</td>
<td>Representations of the Holocaust (Same as GER 116A)</td>
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<td>+ Comparative Literature 171</td>
<td>Post Colonial Cultures (Same as FR 154G)</td>
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<td>* Comparative Literature 179A</td>
<td>Revolutions: Marx, Nietzsche, Freud (Same as GER 179A)</td>
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<td>* Comparative Literature 186RR</td>
<td>Romantic Revolutions: Philosophy, History, and the Arts in Europe</td>
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<td>* East Asian Cultural Studies 3</td>
<td>Introduction to Asian Religious Traditions (Same as RG ST 3)</td>
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<td>* East Asian Cultural Studies 4A</td>
<td>East Asian Traditions: Pre-Modern</td>
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<td>* East Asian Cultural Studies 4B</td>
<td>East Asian Traditions: Modern</td>
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<td>* East Asian Cultural Studies 5</td>
<td>Introduction to Buddhism</td>
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<td>+ East Asian Cultural Studies 7</td>
<td>Asian Values</td>
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<td>* East Asian Cultural Studies 21</td>
<td>Zen</td>
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<td>* East Asian Cultural Studies 80</td>
<td>East Asian Civilization (Same as HST 80)</td>
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<tr>
<td>+ East Asian Cultural Studies 164B</td>
<td>Buddhist Traditions in East Asia</td>
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<td>English 23</td>
<td>The Climate Crisis: What it is and what each of us can do about it</td>
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<td>^ English 22</td>
<td>Introduction to Literature and the Environment</td>
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<td>English 24I</td>
<td>Introduction to Literature and the Environment, Part 2, World Perspectives</td>
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<tr>
<td>&amp; English 34</td>
<td>Pan-Latinx Literatures</td>
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<td>English 34NA</td>
<td>Animacy and the Speaking Earth: The Power of Native Story Experiences</td>
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<td>* English 171</td>
<td>Literature and the Human Mind</td>
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<td>* Environmental Studies 3</td>
<td>Introduction to the Social and Cultural Environment</td>
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<td>* Feminist Studies 171CN</td>
<td>Citoyennes! Women and Politics in Modern France (Same as FR 155D)</td>
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<tr>
<td>French 40X</td>
<td>Memory: Bridging the Humanities and Neuroscience (Same as C LIT 27 &amp; MCDB 27)</td>
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<td>^ French 30AX-BX-CX</td>
<td>Tales of Love</td>
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<td>* French 149C</td>
<td>Reading Paris (1830-1890)</td>
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<td>* French 154F</td>
<td>Time Off in Paris</td>
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<td>* French 154G</td>
<td>French 154I</td>
<td>Post-Colonial Cultures (Same as C LIT 171)</td>
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**Area F: Arts (1 course minimum)**

Objective: To develop an appreciation of fine and performing arts, popular arts, and visual culture and to express relationships between arts and historical or cultural contexts.

- **Art 1A** Visual Literacy
- **Art 7A** The Intersections of Art and Life
- **Art 106W** Introduction to 2D/3D Visualizations in Architecture
- **Art 125** Art Since 1950
- **Art History 1** Introduction to Art
- **Art History 5A** Introduction to Architecture and the Environment
- **Art History 5B** Introduction to Museum Studies
- **Art History 6A** Art Survey I: Ancient Art-Medieval Art
- **Art History 6B** Art Survey II: Renaissance-Arts and Cultures of the Americas
- **Art History 6C** Art Survey III: Modern-Contemporary Art
- **Art History 6D** Survey: History of Art in China
- **Art History 6E** Survey: Art of Japan and Korea
- **Art History 6F** Survey: Arts in Africa, Oceania, and Native North America
- **Art History 6G** Sydney Architecture and Planning
- **Art History 6H** Survey: History of Photography
- **Art History 6I** Pre-Columbian Art
- **Art History 6J** Survey: Contemporary Architecture
- **Art History 6K** Islamic Art and Architecture
- **Art History 6L** History of Games
- **Art History 6M** Rome: The Game
- **Art History 6N** Roman Architecture
- **Art History 6O** Roman Art: From the Republic to Empire (509 BC to AD 327)
- **Art History 6P** Greek Architecture
- **Art History 6Q** Medieval Architecture: From Constantine to Charlemagne
- **Art History 6R** The Origins of Romanesque Architecture
- **Art History 6S** Late Romanesque and Gothic Architecture
- **Art History 6T** Art and Society in Late Medieval Tuscany
- **Art History 6U** Painting in Fifteenth-Century Netherlands
- **Art History 6V** Painting in Sixteenth-Century Netherlands
- **Art History 6W** The French Renaissance 1400-1500
- **Art History 6X** Italian Renaissance 1400-1600
- **Art History 6Y** Art as Technique, Labor, and Idea in Renaissance Italy
- **Art History 6Z** Art and the Formation of Social Subjects in Early Modern Italy
- **Art History 7A** Michelangelo
- **Art History 7B** Italian Journeys
- **Art History 7C** Leonardo da Vinci: Art, Science and Technology in Early Modern Italy
- **Art History 7D** Dutch Art in the Age of Rembrandt
- **Art History 7E** Dutch Art in the Age of Vermeer
- **Art History 7F** Rethinking Rembrandt
- **Art History 7G** Seventeenth-Century Art in Southern Europe
- **Art History 7H** Seventeenth-Century Art in Italy
- **Art History 7I** Bernini and the Age of the Baroque
- **Art History 7J** Eighteenth-Century Art 1750-1810
- **Art History 7K** Eighteenth-Century British Art and Culture
- **Art History 7L** Eighteenth-Century Art in Italy: The Age of the Grand Tour
- **Art History 7M** Nineteenth-Century Art 1848-1900
- **Art History 7N** Nineteenth-Century British Art and Culture
- **Art History 7O** Impressionism and Post-Impressionism
- **Art History 7P** Contemporary Art
- **Art History 7Q** Expressionism to New Objectivity, Early Twentieth-Century German Art
- **Art History 7R** Art in the Post-Modern World
- **Art History 7S** Early Twentieth-Century European Art 1900-1945
- **Art History 7T** Art of the Postwar Period 1945-1968
- **Art History 7U** Critical Approaches to Visual Culture
- **Art History 7V** American Art from the Revolution to Civil War: 1700-1860
- **Art History 7W** Reconstruction, Renaissance, and Realism in American Art 1860-1900
**Art History 121C**
Twentieth-Century American Art: Modernism and Pluralism 1900-Present

& **Art History 121D**
African-American Art and the African Legacy

+ **Art History 121E**
Three Dimensional Arts of the United States

& **Art History 121F**
Pre-Columbian Art of Mexico

+ **Art History 121G**
Pre-Columbian Art of the Maya

& **Art History 121C**
The Arts of Spain and New Spain

+ **Art History 121D**
Pre-Columbian Art of South America

+ **Art History 121A**
Mediterranean Cities

+ **Art History 121B**
Art of Empire

+ **Art History 121C**
Buddhist Art

+ **Art History 121B**
Early Chinese Art

+ **Art History 121C**
Chinese Painting

+ **Art History 121D**
Art and Modern China

+ **Art History 121E**
The Art of the Chinese Landscape

+ **Art History 121F**
The Art of Japan

+ **Art History 121G**
Japanese Painting

+ **Art History 121H**
Ukiyo-e: Pictures of the Floating World

+ **Art History 121A**
Nineteenth-Century Architecture

+ **Art History 121B**
Twentieth-Century Architecture

+ **Art History 121C**
Architecture of the United States

+ **Art History 121D**
Design & the American Architect

& **Art History 121E**
Housing American Cultures

+ **Art History 121F**
The City in History

*Art History 121K*
Landscape of Colonialism

*Art History 121L*
Modern Architecture in Early Twentieth-Century Europe

*Art History 121M*
From Modernism to Postmodernism in European Architecture

Art History 121N
Revival Styles in Southern California Architecture

Art History 121O
Sustainable Architecture: History and Aesthetics

Art History 121P
Architecture of the Americas

+ Art History 121Q
Modern Indian Visual Culture

Art History 121R
Introduction to 2D/3D Visualizations in Architecture

Art History 121S
Modern Architecture in Southern California

Art History 121T
Birth of the Modern Museum

*Art History 121U*
The Architecture of Museums and Galleries from c. 1800 to the Present

Art History 121V
The Avant-Garde in Russia

Art History 121W
Contemporary Art in Russia and Eastern Europe (Same as SLAV 130C)

Art History 121X
Russian Art

Art History 121Y
Contemporary Art History: 1960-2000

Art History 121Z
Global Art After 1980

* Asian American Studies 4
Introduction to Asian American Popular Culture

& Asian American Studies 7
Introduction to Playwriting

& Asian American Studies 11
Asian Americans in Popular Culture

& Asian American Studies 12
Asian American Documentary

& Asian American Studies 13
Asian American Film, Television, and Digital Media

& Asian American Studies 14
Theory & Production of Social Experience

& Asian American Studies 15
Racialized Sexuality on Screen and Stage

& Asian American Studies 170XX
Special Topics in Asian American Studies

* Black Studies 1
History of Jazz

* Black Studies 45
Black Arts Expressions

* Black Studies 142
Music in African American Culture: U.S.A.

* Black Studies 153
Black Popular Music in America

* Black Studies 161
Third-World Cinema

* Black Studies 162
African Cinema

* Black Studies 170
Afro-Americans in the American Cinema

* Black Studies 171
Afre in Film

* Black Studies 172
Contemporary Black Cinema

* Black Studies 175
Black Diaspora Cinema

& Chicano Studies 125B
Contemporary Chicano and Chicana Art

& Chicano Studies 138
Barrio Popular Culture

& Chicano Studies 148
Chicana Art and Feminism

& Chicano Studies 188B
Chicano Theater Workshop

* Chinese 40
Popular Culture in Modern Chinese Societies

* Chinese 170
New Taiwan Cinema

+ Chinese 176
Chinese Cinema: Nationalism and Globalism

* Classics 102
Greek Tragedy in Translation

* Classics 165
Greek Painting

* Classics 170
Pompeii

+ Comparative Literature 186FF
NOIR: 1940's Film and Fiction

+ Dance 35
History and Appreciation of World Dance

* Dance 36
History of Modern Dance

* Dance W36
History of Modern Dance (online course)

+ Dance 45
History and Appreciation of Dance

+ Dance 145A-B
Studies in Dance History

+ East Asian Cultural
Buddhist Art

Studies 134A
Sustainable Architecture: History and Aesthetics

* Film & Media Studies 46
Introduction to Cinema

* Film & Media Studies 55AA-ZZ
Media Arts: The High and the Low

* Film & Media Studies 56AA-ZZ
Media Cultures and Thought

* Film & Media Studies 120
Japanese Cinema (Same as JAPAN 159)

* Film & Media Studies 121
Comparative Studies

* Film & Media Studies 122AA-ZZ
Topics in National Cinema

* Film & Media Studies 124
Indian Cinema

* Film & Media Studies 124V
Modern Indian Visual Culture

* Film & Media Studies 125A-B
Documentary Film

* Film & Media Studies 126
Classical Hollywood

& Film & Media Studies 127
Latin American Cinema

* Film & Media Studies 127M
Mexican Film and Cinema

* Film & Media Studies 134
French and Francophone Cinema

* Film & Media Studies 136
British Cinema

* Film & Media Studies 144
The Horror Film (Same as GER 183)

* Film & Media Studies 163
Women and Film: Feminist Perspectives

Film & Media Studies 169
Film Noir

Film & Media Studies 175
Experimental Film

* Film & Media Studies 178Z
Technology and Cinema (Same as FR 156D)

* French 156A
French Cinema: History and Theory

* French 156C
French and Francophone Cinema

* French 156D
Modern Images of the Middle Ages: The Intersection of Text, History, and Film

* French 156D
Technology and Cinema (Same as FLMST 1782)

* German 55A
Contemporary German Pop Culture

Italian 124X
Italian Theatre

Italian 178B
Italian Cinema

Italian 179X
Fiction and Film in Italy

Italian 180Z
Italian Cinema

+ Japanese 134F
Arts of Japan (Same as ARTHI 134F)

+ Japanese 134G
Japanese Painting (Same as ARTHI 134G)

+ Japanese 134H
Ukiyo-e: Pictures of the Floating World (Same as ARTHI 134H)

+ Japanese 149
Traditional Japanese Drama

+ Japanese 159
Japanese Cinema (Same as FLMST 120)

Japanese 159A
Postwar Japanese Cinema (1945-1965)

+ Korean 75
Introduction to Popular Culture in Korean Film

* Music 3B
Writing about Music

* Music 11
Fundamentals of Music

* Music 15
Music Appreciation

* Music 16
Listening to Jazz: Demystifying America's Musical Art Form

Music 17
World Music

* Music 113A
The History of Opera: 1600-1800

* Music 114
Music and Popular Culture in America

* Music 115
Symphonic Music

* Music 116
American Music History: Colonial to Present

* Music 118A
History and Literature of Great Composers in Western Music

* Music 119A
Music and Politics

Music 119B
Music in Political Films

Religious Studies 13
Religion and Popular Culture

& Religious Studies 133B
From Superman to Speigelman: The Jewish Graphic Novel

* Religious Studies 157G
Persian Cinema

Slavic 130A
The Avantgarde in Russia

Slavic 130B
Russian Cinema

Slavic 130C
Contemporary Art in Russia and Eastern Europe (Same as ARTHI 144C)

Slavic 130D
Russian Art

Slavic 130E
Masters of Soviet Cinema

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**Spanish 126**  
Spanish Cinema  
+ **Theater 2A**  
Performance in Global Contexts: Africa and the Caribbean  
* **Theater 2B**  
Performance in Global Contexts: Asia  
* **Theater 2C**  
Performance in Global Contexts: Europe  
* **Theater 3**  
Life of the Theater  
* **Theater 5**  
Introduction to Acting  
* **Theater 7**  
Performance of the Human Body  
* **Theater 9**  
Introduction to Playwriting  
* **Theatre 143**  
The People’s Voice  
* **Theater 180A-B**  
American Drama  
& **Theater 180C**  
Contemporary American Drama and Theater  
&* **Theater 180E**  
Culture Clash: Studies in U.S. Latino Theater  
&* **Theater 180G**  
Race, Gender, and Performance  
* **Theater 182A**  
Ancient Theater and Drama  
* **Theater 182M**  
Modern Theater and Drama  
* **Theater 182MC**  
Modern Contemporary  
* **Theater 182N**  
Neoclassical Theater and Drama  
&* **Theater 184AA**  
African American Performance  
* **Theater 184CA**  
Contemporary African Theater and Performance  
* **Theater 1885**  
Shakespeare on Film and Stage  

**AREA G: LITERATURE (1 course minimum)**

Objective: To learn to analyze texts using methods appropriate to literary study and to situate analysis within contexts where texts circulate.

& **Asian American Studies 5**  
Introduction to Asian American Literature  
* **Asian American Studies 122**  
Asian American Fiction  
* **Asian American Studies 128**  
Writings by Asian American Women  
*+ **Black Studies 33**  
Major Works of African Literatures (Same as C LIT 33)  
&* **Black Studies 38A-B**  
Introduction to Afro-American Literature  
*+ **Black Studies 126**  
Comparative Black Literatures  
*+ **Black Studies 127**  
Black Women Writers  
*+ **Black Studies 130A**  
Negritude and African Literature  
+ **Black Studies 130B**  
The Black Francophone Novel  
& **Chicano Studies 152**  
Postcolonialism  
& **Chicano Studies 180**  
Survey of Chicano Literature  
& **Chicano Studies 181**  
The Chicano Novel  
& **Chicano Studies 184A**  
Chicana Writers  
+ **Chinese 35**  
Introduction to Taiwan Literature  
+ **Chinese 80**  
Masterpieces of Chinese Literature  
*+ **Chinese 115A**  
Imagism, Haiku, and Chinese Poetry  
*+ **Chinese 124A-B**  
Readings in Modern Chinese Literature  
*+ **Chinese 132A**  
Classical Chinese Poetry  
+ **Chinese 148**  
Historic Lives  
* **Classics 20A**  
The Ancient Greeks  
* **Classics 36**  
Ancient Epic  
* **Classics 39**  
Women in Classical Literature  
* **Classics 40**  
Greek Mythology  
* **Classics 55**  
Troy  
* **Classics 102**  
Viewing the Barbarian: Representations of Foreign Peoples in Greek Literature  
* **Classics 109**  
From Homer to Harlequin: Masculine, Feminine, and the Romance  
* **Classics 110**  
Comedy and Satire in Translation  
* **Classics 130**  
Ancient Theories of Literature  
*+ **Classics 175**  
Major Works of European Literature  
*+ **Comparative Literature 31**  
Major Works of Asian Literatures  
*+ **Comparative Literature 32**  
Major Works of Middle Eastern Literatures  
*+ **Comparative Literature 33**  
Major Works of African Literatures (Same as BL ST 33)  
* **Comparative Literature 34**  
Literature of the Americas  
*+ **Comparative Literature 100**  
Introduction to Comparative Literatures  
*+ **Comparative Literature 103**  
New Novel: Epistolary Narratives (Same as ENGL 126BN)  
* **Comparative Literature 107**  
Voyages to the Unknown  
*+ **Comparative Literature 113**  
Trauma, Memory, Historiography  
*+ **Comparative Literature 122A**  
Representations of the Holocaust (Same as GER 116A)  
*+ **Comparative Literature 122B**  
Holocaust in France (Same as FR 154E)  
*+ **Comparative Literature 126**  
Comparative Black Literatures  
*+ **Comparative Literature 128A**  
Children’s Literature  
*+ **Comparative Literature 133**  
Transpacific Literature  
*+ **Comparative Literature 146**  
Robots  
&* **Comparative Literature 153**  
Border Narratives  
* **Comparative Literature 154**  
Science Fiction in Eastern Europe  
* **Comparative Literature 161**  
Literature of Central Europe  
* **Comparative Literature 170**  
Literary Translation: Theory and Practice  
*+ **Comparative Literature 171**  
Post-Colonial Cultures (Same as FR 154D)  
*+ **Comparative Literature 179A**  
Revolutions: Marx, Nietzsche, Freud (Same as GER 179A)  
* **Comparative Literature 179B**  
Mysticism  
* **Comparative Literature 179C**  
Mediatemother (Same as GER 179C)  
* **Comparative Literature 186AE**  
Interdisciplinary Comparative Literature  
*+ **Comparative Literature 188**  
Narrative Studies  
* **Comparative Literature 189**  
Narrative in the First Person  
* **Comparative Literature 191**  
Fantasy and the Fantastic (Same as FR 153D)  
*+ **English 113AA-ZZ**  
Literate-theory and Criticism  
&* **English 114BW**  
Black Women Authors  
*+ **English 115**  
Medieval Literature  
*+ **English 116A**  
Biblical Literature: The Old Testament  
*+ **English 116B**  
*+ **English 119X**  
Medieval Literature in Translation  
*+ **English 120**  
Modern Drama  
*+ **English 121**  
The Art of Narrative  
*+ **English 122AA-ZZ**  
Cultural Representations  
*+ **English 122NE**  
Cultural Representations of Nature and the Environment (Same as INT 122N)  
*+ **English 124**  
Readings in the Modern Short Story  
*+ **English 126B**  
Survey of British Fiction  
*+ **English 128AA-ZZ**  
Studies in American Literature  
*+ **English 131AA-ZZ**  
Studies in American Regional Literature  
*+ **English 133AA-ZZ**  
Literature of Cultural and Ethnic Communities in the United States  
*+ **English 136**  
Seventeenth and Eighteenth Century  
*+ **English 137AA-ZZ**  
American Literature  
*+ **English 140**  
Poesy in America  
*+ **English 150**  
Contemporary American Literature  
*+ **English 152A**  
Anglo-Irish Literature  
*+ **English 156**  
Chaucer: Canterbury Tales  
*+ **English 157**  
Narrative of Native Story  
*+ **English 162**  
English Renaissance Drama  
*+ **English 165AA-ZZ**  
Studies in Literature and the Mind  
*+ **English 170AA-ZZ**  
Studies in the Enlightenment  
*+ **English 172**  
British Romantic Writers  
*+ **English 179**  
The Victorian Era  
*+ **English 180**  
Studies in the Nineteenth Century  
*+ **English 181AL-MT**  
Modern European Literature  
*+ **English 184**  
Modern European Literature  

* This course applies toward the Writing requirement.  
& This course applies toward the Ethnicity requirement.  
+ This course applies toward the World Cultures requirement.  
@ This course applies toward the American History & Institutions requirement.  
^ This course applies toward the European Traditions requirement.
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Note: These courses do not fulfill requirements for Areas D, E, F, or Special Subject Area Supplementary List of Courses.
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<td>Native American History, 1838 to Present</td>
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<tr>
<td>History 184B</td>
<td>History of China</td>
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<td>INT 36 SAA-ZZ</td>
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<td>Imagining the Samurai</td>
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<td>Japanese 167A</td>
<td>Religion in Japanese Culture</td>
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<td>Japanese 186RW</td>
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<td>Materials in Society: The Stuff of Dreams</td>
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<td>Molecular, Cellular, and Developmental Biology 134H</td>
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<td>Democracy and Diversity</td>
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<td>The American Presidency</td>
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<td>Power in Washington</td>
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<td>Asian American Politics</td>
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<td>Political Science 161</td>
<td>U.S. Minority Politics</td>
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<td>Urban Government and Politics</td>
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<td>Criminal Justice</td>
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<td>Bureaucracy and Public Policy</td>
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<tr>
<td>Religious Studies 110D</td>
<td>Ritual Art and Verbal Art of the Pacific Northwest</td>
</tr>
<tr>
<td>Religious Studies 114D</td>
<td>Religion in Japanese Culture</td>
</tr>
<tr>
<td>Religious Studies 127B</td>
<td>Christian Thought and Cultures of the Middle Ages</td>
</tr>
<tr>
<td>Religious Studies 131F</td>
<td>The History of Anti-Semitism</td>
</tr>
<tr>
<td>Religious Studies 131J</td>
<td>Introduction to Rabbinic Literature</td>
</tr>
<tr>
<td>Religious Studies 140A</td>
<td>Islamic Traditions</td>
</tr>
<tr>
<td>Religious Studies 140B</td>
<td>Religion, Politics, and Society in the Persian Gulf Region</td>
</tr>
<tr>
<td>Religious Studies 140C</td>
<td>Islamic Mysticism and Religious Thought</td>
</tr>
<tr>
<td>Religious Studies 140D</td>
<td>Islam in South Asia</td>
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<tr>
<td>Religious Studies 140E</td>
<td>Islam in America</td>
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<tr>
<td>Religious Studies 140F</td>
<td>Modern Islamic Movements</td>
</tr>
<tr>
<td>Religious Studies 145</td>
<td>Patterns in Comparative Religion</td>
</tr>
<tr>
<td>Religious Studies 149R</td>
<td>Islamic Philosophy and Theology</td>
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<tr>
<td>Religious Studies 160A</td>
<td>Religious Traditions of India</td>
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<tr>
<td>Religious Studies 162A</td>
<td>Indian Philosophy</td>
</tr>
<tr>
<td>Religious Studies 166C</td>
<td>Confucian Traditions: The Classical Period</td>
</tr>
</tbody>
</table>

* This course applies toward the Writing requirement.  
& This course applies toward the Ethnicity requirement.  
+ This course applies toward the World Cultures requirement.  
Ω This course applies toward the American History & Institutions requirement.  
^ This course applies toward the European Traditions requirement.
CHECKLIST OF GENERAL UNIVERSITY AND GENERAL EDUCATION REQUIREMENTS

GENERAL UNIVERSITY REQUIREMENTS

*UC Entry Level Writing Requirement* – (Must be fulfilled within three quarters of admission.)

Passed Exam ________ or Writing 1, 1E or Ling 12 _________ or transferred appropriate course ________

*American History and Institutions* – (Refer to page 8 for the list of acceptable courses.)

One course ________ or Advanced Placement _________ or International waiver ________

*This course may also apply to the General Education requirements, if appropriate.

GENERAL EDUCATION REQUIREMENTS

A course listed in more than one General Subject Area can be applied to only one area. Course total in Areas D, E, F, and G must be at least 6.

General Subject Areas

1. **Area A: English Reading and Composition**
   

2. **Area D: Social Sciences** (2 courses minimum)

3. **Area E: Culture and Thought** (2 courses minimum)

4. **Area F: The Arts** (1 course minimum)

5. **Area G: Literature** (1 course minimum)

Special Subject Areas

In the process of fulfilling the G.E. General Subject Area requirements, students must fulfill the following Special Subject Area requirements, as outlined on page 11. Only approved courses can be used to fulfill these requirements.

a. **Writing Requirement** – (4 courses)

b. **Ethnicity Requirement** – (1 course)

c. **European Traditions or World Cultures Requirement** – (1 course)
Chemical Engineering

Department of Chemical Engineering, Engineering II, Room 3357; (805) 893-3412
www.chemengr.ucsb.edu
Chair: Rachel A. Segalman
Vice-Chairs: Michael J. Gordon, M. Scott Shell

Faculty

Joseph Chada, Ph.D., University of Wisconsin, Lecturer with Potential Security of Employment
Bradley Chmelka, Ph.D., UC Berkeley, Distinguished Professor (self-assembled materials, heterogeneous catalysis, surfactants and polymers, porous and composite solids, magnetic resonance)
Phillip N. Christopher, Ph.D., University of Michigan, Associate Professor (catalysis, photocatalysis, plasmonics, nanomaterials synthesis, in-situ characterization)
Siddharth S. Dey, Ph.D., UC Berkeley, Assistant Professor (systems biology, single-cell genomics, epigenetics, stem cell biology)
Michael F. Doherty, Ph.D., Cambridge University, Distinguished Professor (process design and synthesis, separations, crystal engineering)
Glenn Fredrickson, Ph.D., Stanford University, Distinguished Professor (polymer theory, block copolymers, phase transitions, statistical mechanics, glass transitions, composite media)
Michael J. Gordon, Ph.D., California Institute of Technology, Professor (surface physics, scanning probe microscopy, nanoscale materials, plasmonics, laser spectroscopy)
Song-I Han, Ph.D., Aachen University of Technology, Professor (magnetic resonance methods and applications, protein biophysics, spectroscopy)
Matthew E. Helgeson, Ph.D., University of Delaware, Associate Professor (colloidal thermodynamics and rheology, polymer and surfactant self-assembly, nanomaterials, microfluidics)
Eric McFarland, Ph.D., Massachusetts Institute of Technology, M.D., Harvard, Professor (energy production, catalysis, reaction engineering, charge and energy transfer)
Arnab Mukherjee, Ph.D., University of Illinois at Urbana-Champaign, Assistant Professor (protein and cell engineering, genetic tools for molecular imaging, fluorescence imaging, magnetic resonance imaging, anaerobic biosystems, synthetic biology)
Michelle A. O’Malley, Ph.D., University of Delaware, Associate Professor (genetic and cellular engineering, membrane protein characterization for drug discovery, protein biophysics, metagenomics, biofuel production)
James B. Rawlings, Ph.D., University of Wisconsin, Distinguished Professor (chemical process monitoring and control, reaction engineering, computational modeling)
Susannah Scott, Ph.D., Iowa State University, Distinguished Professor (heterogeneous catalysis, surface organometallic chemistry; analysis of electronic structure and stoichiometric reactivity to determine catalytic function)
Rachel A. Segalman, Ph.D., UC Santa Barbara, Professor (polymer design, self-assembly, and properties)
M. Scott Shell, Ph.D. Princeton, Professor (molecular simulation, statistical mechanics, complex materials, protein biophysics)
Todd M. Squires, Ph.D., Harvard, Professor (fluid mechanics, microfluidics, microrheology, complex fluids)
Sho Takatori, Ph.D., California Institute of Technology, Assistant Professor (statistical mechanics and fluid dynamics of biological systems, microbial and cellular communities)

Emeriti Faculty

Sanjoy Banerjee, Ph.D., University of Waterloo, Professor Emeritus (transport processes, multiphase systems, process safety)
Owen T. Hanna, Ph.D., Purdue University, Professor Emeritus (theoretical methods)
Gene Lucas, Ph.D., Massachusetts Institute of Technology, Professor (structural materials, mechanical properties)
L. Gary Leal, Ph.D., Stanford University, Schlumberger Distinguished Professor in Chemical Engineering (fluid mechanics, physics of complex fluids, rheology)
Duncan A. Mellichamp, Ph.D., Purdue University, Professor Emeritus (process dynamics and control, digital computer control)
Robert G. Rinker, Ph.D., California Institute of Technology, Professor Emeritus (chemical kinetics, reaction engineering, catalysis)
Orville C. Sandall, Ph.D., UC Berkeley, Professor Emeritus (transport of mass, energy, and momentum; separation processes)
Dale E. Seborg, Ph.D., Princeton University, Professor Emeritus (process dynamics and control, monitoring and fault detection, system identification)
Theofanis G. Theofanous, Ph.D., University of Minnesota, Professor, Center for Risk Studies and Safety Director (transport phenomena in multiphase systems, risk analysis)

Affiliated Faculty

Christopher Bates, Ph.D. (Materials)
David Gay, Ph.D. (ICB)
Mahdi Abu Omar, Ph.D. (Chemistry)
Philip Alan Pincus, Ph.D. (Materials)

We live in a technological society which provides many benefits including a very high standard of living. However, our society must address critical problems that have strong technological aspects. These problems include: meeting our energy requirements, safeguarding the environment, ensuring national security, and delivering health care at an affordable cost. Because of their broad technical background, chemical engineers are uniquely qualified to make major contributions to the resolution of these and other important problems. Chemical engineers develop processes and products that transform raw materials into useful products.

The Department of Chemical Engineering offers the B.S., M.S., and Ph.D. degrees in chemical engineering. The B.S. degree is accredited by the Engineer Accreditation Commission of ABET, http://www.abet.org.

At the undergraduate level, emphasis is placed on a thorough background in the fundamental principles of science.
and engineering, strongly reinforced by laboratory courses in which students become familiar with the application of theory. At the graduate level, students take advanced courses and are required to demonstrate competence in conducting basic and applied research. The B.S. degree provides excellent preparation for both challenging industrial jobs and graduate degree programs. Interdisciplinary B.S./M.S. degree programs are also available which result in M.S. degrees in other fields. Students who complete a major in chemical engineering may be eligible to pursue a California teaching credential. Interested students should consult the credential advisor in the Graduate School of Education as soon as possible.

Under the direction of the Associate Dean for Undergraduate Studies, academic advising services are jointly provided by advisors in the College of Engineering, as well as advisors in the department. Each undergraduate also is assigned a faculty advisor, to assist in selection of elective courses, plan academic programs, and provide advice on professional career objectives. Undergraduates in other majors who plan to change to a major in the Department of Chemical Engineering should consult the department academic advisor for the requirements.

Mission Statement

The program in Chemical Engineering has a dual mission:

- **Education.** Our program seeks to produce chemical engineers who will contribute to the process industries worldwide. Our program provides students with a strong fundamental technical education designed to meet the needs of a changing and rapidly developing technological environment.

- **Research.** Our program seeks to develop innovative science and technology that addresses the needs of industry, the scientific community, and society.

Objectives for the Undergraduate Program

Educational Objectives

- Our graduates will be innovative, competent, contributing chemical engineers.
- Our graduates will demonstrate their flexibility and adaptability in the workplace, so that they remain effective engineers, take on new responsibilities, and assume leadership roles.
- Our graduates will continually develop new skills and knowledge through formal and informal mechanisms.

**Student Outcomes**

Upon graduation, students from the ChE program at UCSB are expected to have:

1. An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.
2. An ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors.
3. An ability to communicate effectively with a range of audiences.
4. An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts.
5. An ability to function effectively on a team whose members together create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives.
6. An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering to draw conclusions.
7. An ability to acquire and apply new knowledge as needed, using appropriate learning strategies.

**Undergraduate Program**

**Bachelor of Science—Chemical Engineering**

A minimum of 187 units is required for graduation. A complete list of requirements for the major can be found on page 46. Schedules should be planned to meet both General Education and major requirements. Courses required for the major, inside or outside of the Department of Chemical Engineering, cannot be taken for the pass/not pass grading option. They must be taken for letter grades.

Fifteen units of technical electives selected from a wide variety of upper-division science and engineering courses are also required. The list of approved technical electives is included on curriculum sheets. Prior approval of technical electives must be obtained from the department faculty advisor and the technical elective worksheet must be submitted to the department by fall quarter of the senior year.

Transfer students who have completed most of the lower-division courses listed above and are entering the junior year of the chemical engineering program may take Chemical Engineering 10 concurrently with Chemical Engineering 120A in the fall quarter.

**Chemical Engineering Courses**

**LOWER DIVISION**

5. **Introduction to Chemical Engineering Design**

   (3) DOHERTY, SHELL, CHADA

   Introduction to the design and analysis of processes involving chemical change in the context of chemical and biomolecular engineering. Students learn mathematical, empirical, and conceptual strategies to analyze.

10. **Material & Energy Balances**

    (3) GORDON, CHADA

    Prerequisites: Chemical Engineering 5 (May be taken concurrently); Chemistry 1A-B-C or 2A-B-C; Mathematics 2A or 3A, Mathematics 2B or 3B, and Mathematics 4A or 4AII; Space may be limited and registration priority will be given to Chemical engineering and CoE majors.

    Elementary principles of chemical engineering. The major topics discussed include material and energy balances, stoichiometry, and thermodynamics.

99. **Introduction to Research**

    (1-3) STAFF

    Prerequisites: consent of instructor and undergraduate advisor.

    May be repeated for credit to a maximum of 6 units. Students are limited to 5 units per quarter and 30 units total in all 99/199/199H/199D/199RA courses combined.

    Directed study, normally experimental, to be arranged with individual faculty members. Course offers exceptional students an opportunity to participate in a research group.

**UPPER DIVISION**

102. **Biomaterials and Biosurfaces**

    (3) STAFF

    Recommended Preparation: Basic physical chemistry, biology, physics, thermodynamics and biology.

    Not open for credit to students who have completed Chemical Engineering 121.

    Fundamentals of natural and artificial biomaterials and surfaces with emphasis on molecular level structure and function and the interactions of biomaterials and surfaces with the body. Design issues of grafts and biopolymers. Basic biological and biochemical systems reviewed for biologists.

107. **Introduction to Biological Processing**

    (3) O’MALLEY, DEY

    Prerequisites: Chemical Engineering 10

    Familiarizes engineering students with biological processing and production at multiple scales. Chemical engineering principles will be infused with key biological concepts, including an introduction to biochemical engineering and CoE majors.

110A. **Chemical Engineering Thermodynamics**

    (3) SHELL

    Prerequisite: Chemical Engineering 5, Chemical Engineering 10, Mathematics 4B or 4BI; Space may be limited and registration priority will be given to Chemical engineering and CoE majors.

    Use of the laws of thermodynamics to analyze processes encountered in engineering practice, including cycles and flows. Equations-of-state for describing properties of fluids and mixtures. Applications, including engines, turbines, refrigeration and power plant cycles, phase equilibria, and chemical-reaction...
Thermodynamics, kinetics, mass and energy transport considerations associated with complex homogeneous and heterogeneous reacting systems. Catalysis and catalytic reaction rates and mechanisms. Adsorption and reaction at solid surfaces, including effects of diffusion in porous materials. Chemical reactors using heterogeneous catalysts.

141. The Science and Engineering of Energy Conversion
(3) McFarland, Christopher
Prerequisite: Chemical Engineering 110A and 140A.
Equivalent upper-division coursework in thermodynamics and kinetics from outside of department will be considered.

Framework for understanding the energy supply issues facing society with a focus on the science, engineering, and economic principles of the major alternatives. Emphasis will be on the physical and chemical fundamentals of energy conversion technologies.

146. Heterogenous Catalysis
(3) STAFF
Prerequisite: Chemical Engineering 140A-B or consent of instructor.

Concepts and definitions. Physical and chemical methods of catalyst characterization. Adsorption, desorption, and surface reaction on well-defined surfaces. Thermodynamic and kinetic treatments of overall reactions on uniform and nonuniform surfaces. Correlations and theoretical approaches in chemical engineering catalysis.

152A. Process Dynamics and Control
(4) CHMELKA, Christopher
Prerequisite: Chemical Engineering 120A-C and 140A.

Development of theoretical and empirical models for chemical and physical processes, dynamic behavior of processes, transfer function and block diagram representation, process instrumentation, control system design and analysis, stability analysis, computer simulation of controlled processes.

152B. Advanced Process Control
(3) RAWLINGS
Prerequisite: Chemical Engineering 152A.
The theory, design, and experimental application of advanced process control strategies including feedback control, cascade control, enhanced single- loop strategies, and model predictive control. Analysis of multi-loop control systems. Introduction to on-line optimization.

154. Engineering Approaches to Systems Biology
(3) STAFF
Prerequisite: Chemical Engineering 107, Mathematics 4B or 4BI, Mathematics 6A or 6AI, and Mathematics 6B.
Applications of engineering tools and methods to solve problems in systems biology. Emphasis is placed on integrative approaches that address multi-scale and multi-phenomena in biological regulation. Modeling, optimization, and sensitivity analysis tools are introduced.

160. Introduction to Polymer Science
(3) Segalman
Prerequisite: Chemical Engineering 110A or Chemistry 113A or equivalent.
The same course as Materials 160.
Introductory course covering synthesis, characterization, structure, and mechanical properties of polymers. The course is taught from a materials perspective and includes polymer thermodynamics, chain architecture, measurement and control of molecular weight as well as crystallization and glass transitions.

166. Mechatronics and Instrumentation for Chemical Engineers
(3) Gordon
Prerequisite: Engineering 3 and Chemical Engineering 110A and B, or consent of instructor.
Recommended Preparation: Chemical Engineering 120A and B and Chemical Engineering 132A and B.

Enrollment Comments: Concurrently offered with Chemical Engineering 26A.

Introduction to electromechanical systems and instrumentation used in Chemical Engineering. Fundamentals of transducers, sensors and actuators; interfacing and controlling hardware with software (Arduino & Matlab programming); analog and digital circuits; hands-on electrical and mechanical design, prototyping, and construction. Students produce a final computer-controlled electromechanical project of their own design, or in conjunction with a ChE-faculty research laboratory.

171. Introduction to Biochemical Engineering (3) DEY, O’MALLEY
Prerequisite: Chemical Engineering 107 or MCDB 1A.
Introduction to biochemical engineering covering cell growth kinetics, bioreactor design, enzyme processes, biotechnologies for modification of cellular information, and molecular and cellular engineering.

173. Omics-Enabled Biotechnology (3) O’MALLEY
Prerequisite: Chemical Engineering 107 or MCDB 1A.
This course will integrate genomic, transcriptomic, metabolomic, and proteomic approaches to quantitatively and understand intricate biological systems.

174. Model-Guided Engineering of Biological Systems (3) MUKHERJEE
Prerequisites: Chemical Engineering 10; Chemical Engineering 107 or equivalent, or consent of instructor.
Introduces students to fundamental principles underlying synthetic biology with an emphasis on mathematical modeling of gene regulation using differential equations and mass action kinetics. Students will also learn to design and predict the functional outcomes of synthetic gene circuits and review primary literature in the field.

180A Chemical Engineering Laboratory (3) STAFF
Prerequisites: Chemical Engineering 110A and 120A-B.
Experiments in thermodynamics, fluid mechanics, heat transfer, mass transfer, and chemical processing. Analysis of results, and preparation of reports.

180B Chemical Engineering Laboratory (3) STAFF
Prerequisites: Chemical Engineering 120C, 128, 140A, and 152A.
Experiments in mass transfer, reactor kinetics, process control, and chemical and biochemical processing. Analysis of results and preparation of reports.

184A. Design of Chemical Processes (3) DOHERTY, MCFARLAND, CHADA
Prerequisites: Chemical Engineering 110A-B, 120A-B-C, 128, 132B, 140A-B, and 152A.

184B. Design of Chemical Processes (3) DOHERTY, MCFARLAND, CHADA
Prerequisites: Chemical Engineering 184A.
The solution to comprehensive plant design problems. Use of computer process simulators. Optimization of plant design, investment and operations.

193. Internship in Industry (1-4) STAFF
Prerequisite: Consent of Department.
Enrollment Comments: Student must have a minimum 3.0 GPA. May not be used as departmental elective. May be repeated to a maximum of 12 units. Special projects for selected students. Offered in conjunction with engineering practice in selected industrial and research firms, under direct faculty supervision. A 2-4 page paper and an evaluation from the supervisor will be required for credit.

196. Undergraduate Research (2-4) STAFF
Prerequisite: Upper-division standing, completion of 2 upper-division courses in Chemical Engineering; consent of the instructor.
Must have a minimum 3.0 grade-point average for the preceding three quarters. May be repeated for up to 12 units. Not more than 3 units may be applied to departmental electives.
Research opportunities for undergraduate students. Students will be expected to give regular oral presentations, actively participate in a weekly seminar, and prepare at least one written report on their research.

198. Independent Studies in Chemical Engineering (1-5) STAFF
Prerequisites: consent of instructor; upper-division standing; completion of two upper-division courses in chemical engineering. Must have a minimum 3.0 grade-point-average for the preceding three quarters. May be repeated up to twelve units. Students are limited to five units per quarter and 30 units total in all 98/99/198/199/199DC/199RA courses combined. Directed individual studies.

GRADUATE COURSES

Graduate courses for this major can be found in the UCSB General Catalog.
Computer Engineering

Faculty

Jonathan Balkind, Ph.D., Princeton University, Assistant Professor (Computer Architecture, Programming Languages, and Operating Systems)

Kaustav Banerjee, Ph.D., UC Berkeley, Professor (high performance VLSI and mixed signal system-on-chip designs and their design automation methods; single electron transistors; 3D and optoelectronic integration)

Forrest D. Brewer, Ph.D., University of Illinois at Urbana-Champaign, Professor (VLSI and computer system design automation, theory of design and design representations, symbolic techniques in high level synthesis)

Tevfik Bultan, Ph.D., University of Maryland, College Park, Professor (specification and automated analysis of concurrent systems, computer-aided verification, model checking)

Kerem Camsari, Ph.D., Purdue University, Assistant Professor (Nanoelectronics, Spintronics, Emerging Technologies for Computing, Digital & Mixed-signal VLSI, Neuromorphic & Probabilistic Computing, Quantum Computing, Hardware Acceleration)

Yufei Ding, Ph.D., North Carolina State University, Assistant Professor (high-level large-scale program optimizations, highperformance domain-specific languages, heterogeneous massively parallel computing, high-performance machine learning, and quantum computing)

Yogananda Isukapalli, Ph.D., UC San Diego (Low power hardware design, Multi-antenna wireless communications, Transmit beam forming, Vector quantization, Performance analysis of communication systems)


Chandra Krintz, Ph.D., University of California, San Diego, Professor (dynamic and adaptive compilation systems, high-performance internet (mobile) computing, runtime and compiler optimizations for Java/CIL, efficient mobile program transfer formats)

Peng Li, Ph.D., Carnegie Mellon University, Professor (Integrated circuits and systems, learning algorithms and circuits for brain-inspired computing, electronic design automation, computational brain modeling, hardware machine learning systems)

Behrooz Parhami, Ph.D., UC Los Angeles, Professor (parallel architectures and algorithms, computer arithmetic, computer design, dependable and fault-tolerant computing)

Tim Sherwood, Ph.D., UC San Diego, Professor (computer architecture, dynamic optimization, network and security processors, embedded systems, program analysis and characterization, and hardware support of software systems)

Dmitri B. Strukov, Ph.D., Stony Brook University, Assistant Professor (hybrid circuits, nanoelectronics, resistance switching devices, memristors, digital memories, programmable circuits, bio-inspired computing)

Luke Theogarajan, Ph.D., Massachusetts Institute of Technology, Associate Professor (low-power analog VLSI, biomimetic nanosystems, neural prostheses, biosensors, block co-polymer synthesis, self-assembly, and microfabrication)

Li-C. Wang, Ph.D., University of Texas at Austin, Professor (design verification, testing, computer-aided design of microprocessors)

Mission Statement

To prepare our students to reach their full potential in computer engineering research and industrial practice through a curriculum emphasizing the mathematical tools, scientific basics, fundamental knowledge, engineering principles, and practical experience in the field.

Educational Objectives

The Computer Engineering Program seeks to produce graduates who:

1) Make positive contributions to society by applying their broad knowledge of computer engineering theories, techniques, and tools.

2) Create processes and products, involving both hardware and software
components, that solve societal and organizational problems effectively, reliably, and economically.

3) Are committed to the advancement of science, technical innovation, lifelong learning, professionalism, and mentoring of future generations of engineers.

4) Understand the ethical, social, business, technical, and human contexts of the world in which their engineering contributions will be utilized.

**Student Outcomes**

Upon graduation, students from the CE program at UCSB are expected to have:

1. An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.

2. An ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors.

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

4. An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgements, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts.

5. An ability to function effectively on a team whose members together create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives.

6. An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering to draw conclusions.

7. An ability to acquire and apply new knowledge as needed, using appropriate learning strategies.

**Undergraduate Program**

**Bachelor of Science—Computer Engineering**

A minimum of 191 units is required for graduation. A complete list of requirements for the major can be found on page 48.

Schedules should be planned to meet both General Education and major requirements.

The curriculum contains a core required of all computer engineers, a choice of at least 48 units of senior year elective courses including completion of two out of ten elective sequences and a senior year capstone design project.

Because the Computer Engineering degree program is conducted jointly by the Department of Computer Science and the Department of Electrical and Computer Engineering, several of the upper-division courses have equivalent versions offered by ECE or CMPSC. These courses are considered interchangeable, but only one such course of a given equivalent ECE/CMPSC pair may be taken for credit.

Courses required for the major, whether inside or outside of the Departments of Electrical and Computer Engineering or Computer Science, must be taken for letter grades. They cannot be taken for the passed/not passed grading option.

The upper-division requirements consist of a set of required courses and a minimum of 48 units (12 classes) of additional departmental elective courses comprised of at least two sequences chosen from a set of eight specialty sequences. Each sequence must consist of two or more courses taken from the same course/sequence group. The department electives must also include a capstone design project (CMPSC 189A-B/ECE 189A-B-C).

Upper-division courses required for the major are: Computer Science 130A; ECE 152A, 154A; either ECE 139 or PSTAT 120A; Engineering 101.

The required departmental electives are taken primarily in the senior year; they permit students to develop depth in specialty areas of their choice. A student's elective course program and senior project must be approved by a departmental faculty advisor. A variety of elective programs will be considered acceptable. Sample programs include those with emphasis in: computer-aided design (CAD); computer systems design; computer networks; distributed systems; programming languages; real-time computing and control; multimedia; and very large-scale integrated (VLSI) circuit design.

The defined sequences from which upper-division departmental electives may be chosen are:

- Computer Systems Design: ECE/CMPSC 153A, ECE 153B
- Computer Networks: CMPSC 176A, CMPSC 176B
- Distributed Systems: CMPSC 171 and one or both of the Computer Networks courses
- Programming Languages: CMPSC 160, 162
- Real-Time Computing & Control: ECE 147A-B
- Multimedia: ECE 178, ECE/CMPSC 181, ECE 160
- VLSI: ECE 122A or ECE 123, ECE 122B
- Signal Processing: ECE 130A-B
- Robotics: ECE 179D, ECE 179P
- Design & Test Automation: ECE 157A, ECE 157B
- Machine Learning: CMPSC 165A, CMPSC 165B
- System Software Architecture: CMPSC 170, CMPSC 171

**Satisfactory Progress & Prerequisites**

A majority of Computer Science and Electrical and Computer Engineering courses have prerequisites which must be completed successfully. Successful completion of prerequisite classes requires a grade of C or better in Mathematics 3A-B and 4A, and a grade of C- or better in ECE classes. Students will not be permitted to take any ECE or CMPSC course if they received a grade of F in one or more of its prerequisites. Students who fail to maintain a grade-point average of at least 2.0 in the major may be denied the privilege of continuing in the major.

**Computer Engineering Courses**

See listings for Computer Science starting on page 28 and Electrical and Computer Engineering starting on page 30.
Computer Science

Department of Computer Science, Harold Frank Hall, Room 2104; (805) 893-4321
www.cs.ucsb.edu
Chair: Tevfik Bultan
Vice Chairs: Ben Hardekopf, Chandra Krintz

Faculty

Divyakant Agrawal, Ph.D., State University of New York at Stony Brook, Distinguished Professor (distributed systems and databases)

Prabhanjan Ananth, Ph.D., University of California, Los Angeles, Glenn and Susanne Culler Glenn and Susanne Culler Chair Assistant Professor (security and cryptography)

Jonathan Balkind, Ph.D., Princeton University (computer architecture, programming languages, operating systems)

Elizabeth Belding, Ph.D., University of California, Santa Barbara, Professor (mobile wireless networking, network performance evaluation, advanced service support, solutions for developing and under-developed regions)

Michael Beyeler, Ph.D., University of California, Irvine, Assistant Professor (human centered and social computing; visual computing and interaction)*6

Tevfik Bultan, Ph.D., University of Maryland, College Park, Professor (software verification, program analysis, software engineering, computer security)

Shiyu Chang, Ph.D., University of Illinois at Urbana-Champaign, Assistant Professor (machine learning, artificial intelligence, natural language processing, computer vision)

Shiyu Chang, Ph.D., University of Illinois at Urbana-Champaign, Assistant Professor (machine learning, artificial intelligence, natural language processing, computer vision)

Shumo Chu, Ph.D., University of Washington, Assistant Professor (database and information systems)

Phillip Conrad, Ph.D., University of Delaware, Senior Teaching Professor (computer science education, web technologies, computer networks and communication, transport protocols, multimedia computing)*1

Wim van Dam, Ph.D., University of Oxford and University of Amsterdam, Professor (quantum computation, quantum algorithms, quantum communication, quantum information theory)*5

Yufei Ding, Ph.D., North Carolina State University, Assistant Professor (high-level large-scale program optimizations, high-performance domain-specific languages, heterogeneous massively parallel computing, high-performance machine learning, and quantum computing)

Amr El Abbadi, Ph.D., Cornell University, Distinguished Professor (Information and data management; distributed systems, cloud computing)

Yu Feng, Ph.D., University of Texas at Austin, Assistant Professor (programming languages and software engineering)

Frederic Gibou, Ph.D., University of California, Los Angeles, Professor (High resolution multiscale simulation, scientific computing, tools and software for computational science and engineering, engineering applications)*2

John R. Gilbert, Ph.D., Stanford University, Professor (combinatorial scientific computing, high-performance graph algorithms, tools and software for computational science and engineering, numerical linear algebra)

Arpit Gupta, Ph.D. Princeton University, Assistant Professor (machine learning and data mining; security and cryptography)

Trinabh Gupta, Ph.D., University of Texas at Austin, Assistant Professor (computer systems with a focus on privacy)

Ben Hardekopf, Ph.D., University of Texas at Austin, Associate Professor (programming languages: design, analysis and implementation)

Tobias Höllerer, Ph.D., Columbia University, Professor (human computer interaction; augmented reality; virtual reality; visualization; computer graphics; 3D displays and interaction; wearable and ubiquitous computing)

Yekaterina Kharitonova, Ph.D., University of Arizona, Assistant Teaching Professor

Chandra Krintz, Ph.D., University of California, San Diego, Professor (programming systems, cloud/edge computing, Internet of Things (IOT), distributed systems, agriculture technology)

Christopher Kruegel, Ph.D., Vienna University of Technology, Professor (computer security, program analysis, operating systems, network security, malicious code analysis and detection)[insert after Kruegel and before Lokshnanov]

Lei Li, Ph.D., Carnegie Mellon University, Assistant Professor (artificial intelligence, machine learning and natural language processing)

Daniel Lokshnanov, Ph.D., University of Bergen, Associate Professor (algorithms, theory of computing)

Diba Mirza, Ph.D., University of California, San Diego, Associate/Assistant Teaching Professor

Linda R. Petzold, Ph.D., University of Illinois at Urbana-Champaign, Distinguished Professor (modeling, simulation and analysis of multiscale systems in systems biology and engineering)*2

Tim Sherwood, Ph.D., University of California, San Diego, Professor (computer architecture, secure processors, embedded systems, program analysis and characterization)

Ambuj Singh, Ph.D., University of Texas at Austin, Professor (network science, cheminformatics & bioinformatics, graph querying and mining, databases, machine learning)*3

Misha Sra, Ph.D., Massachusetts Institute of Technology, John and Eileen Gerngross Chair Assistant Professor (database and information systems)

Jianwen Su, Ph.D., University of Southern California, Professor (database systems, Web services, workflow management and BPM)

Subhash Suri, Ph.D., Johns Hopkins University, Distinguished Professor (algorithms, networked sensing, data streams, computational geometry, game theory)

Giovanni Vigna, Ph.D., Politecnico di Milano, Professor (computer and network security, intrusion detection, vulnerability, analysis and security testing, web security, malware detection)

Eric Vigoda, Ph.D., University of California, Berkeley, Professor (randomized algorithms, computational complexity)

Richert K. Wang, Ph.D.,
York-Fang Wang, Ph.D., University of Texas at Austin, Professor (computer vision, computer graphics, artificial intelligence)

Ying-Tsung Yao, Ph.D., University of California, Berkeley, Professor Emeritus (computer vision, pattern recognition, image interpretation, computational intelligence)

Yu-Xiang Wang, Ph.D., Carnegie Mellon University, Eugene Aas Chair Assistant Professor (machine learning, statistics, optimization, artificial intelligence, data science)

William Wang, Ph.D., Carnegie Mellon University, Assistant Professor (natural language processing, machine learning, deep learning, artificial intelligence, knowledge representation and reasoning, information extraction, computational social science, multimodality, language and vision)

Richard Wolski, Ph.D., University of California, Davis/Livermore, Professor (cloud computing, high-performance distributed computing, computational grids, and computational economies for resource allocation and scheduling)

Zoś Wood, Ph.D., California Institute of Technology, Teaching Professor (visual computing and interaction)

Lingqi Yan, Ph.D., University of California, Berkeley, Assistant Professor (computer graphics: realistic/real-time rendering, appearance modeling/measurement, virtual/augmented reality, applied machine learning)

Xifeng Yan, Ph.D., University of Illinois at Urbana Champaign, Professor Emeritus (computer vision, human computer interaction, perceptual computing, artificial intelligence)

Narayanamurti ChairProfessor (Data Science, Machine Learning/AI)

Ph.D., Rutgers University, Assistant Professor (parallel and distributed systems, Internet search, and high performance computing)

Emeriti Faculty

Kevin Almeroth, Ph.D., Georgia Institute of Technology, Professor Emeritus (computer networks and protocols, large-scale multimedia systems, performance evaluation and distributed systems)

Peter R. Cappello, Ph.D., Princeton University, Professor Emeritus (JAVA, internet-based parallel computing, multiprocessor scheduling, market-based resource allocation, self-directed learning)

Ömer Egecioglu, Ph.D., University of California, San Diego, Professor (bijective and enumerative combinatorics, parallel algorithms, approximation algorithms)

Teofilo Gonzalez, Ph.D., University of Minnesota, Professor Emeritus (approximation algorithms; parallel computing, scheduling, theory, placement and routing; optimization, artificial intelligence, data science)

Oscar H. Ibarra, Ph.D., University of California, Berkeley, Professor Emeritus (design and analysis of algorithms, theory of computation, computational complexity, parallel computing)

Richard A. Kemmerer, Ph.D., University of California, Los Angeles, Professor Emeritus (specification and verification of systems, computer system security and reliability, programming and specification language design, software engineering)

Alan G. Konheim, Ph.D., Cornell University, Professor Emeritus (computer communications, computer systems, modeling and analysis, cryptography)

Terence R. Smith, Ph.D., Johns Hopkins University, Professor Emeritus (spatial databases, techniques in artificial machine intelligence)*4

Matthew Turk, Ph.D., Massachusetts Institute of Technology, Professor Emeritus (computer vision, human computer interaction, perceptual computing, artificial intelligence)

*1 Joint appointment with College of Creative Studies
*2 Joint appointment with Mechanical Engineering
*3 Joint appointment with Biomedical Science & Engineering
*4 Joint appointment with Geography
*5 Joint appointment with Physics
*6 Joint appointment with Psychological and Brain Sciences

Affiliated Faculty

Francesco Bullo, Ph.D. (Mechanical Engineering)[insert after Bullo and before Chandrasekaran]

Katie Byl, Ph.D. (Electrical and Computer Engineering)

Shivkumar Chandrasekaran, Ph.D. (Electrical and Computer Engineering)

Miguel Eckstein, Ph.D. (Psychological & Brain Sciences)

Jennifer Jacobs, Ph.D. (Media Arts and Technology)

Kyle Mahowald, Ph.D. (Linguistics)

B.S. Manjunath, Ph.D. (Electrical and Computer Engineering)

Yasamin Mostofi, Ph.D. (Electrical and Computer Engineering)[insert after Sen and before Zhang]

Pradeep Sen, Ph.D. (Electrical and Computer Engineering)

Sharon Tettegah, Ph.D. (Black Studies)

Simon Todd, Ph.D. (Linguistics)

Zheng Zhang, Ph.D. (Electrical and Computer Engineering)

Mission Statement

The Computer Science Department seeks to prepare undergraduate and graduate students for productive careers in industry, academia, and government, by providing an outstanding environment for teaching and research in the core and emerging areas of the discipline. The department places high priority on establishing and maintaining innovative research programs that enhance educational opportunity.

The Department of Computer Science offers programs leading to the degree of Bachelor of Science in computer science, and the M.S. and Ph.D. in computer science. One of the most important aspects of the Computer Science program at UCSB is the wealth of “hands-on” opportunities for students. UCSB has excellent computer facilities. Campus Instructional Computing makes accounts available to all students. Computer Science uses the workstations in the Computer Science Instructional Lab and Engineering Computing Infrastructure computing facilities. Students doing special projects can gain remote access to machines at the NSF Supercomputing Centers.

Additional computing facilities are available for graduate students in the Graduate Student Laboratory. Students working with faculty have access to further specialized research facilities within the
Department of Computer Science.
The undergraduate major in computer science has a dual purpose: to prepare students for advanced studies and research and to provide training for a variety of careers in business, industry, and government.

Under the direction of the Associate Dean for Undergraduate Studies, academic advising services are jointly provided by advisors in the College of Engineering, as well as advisors in the department. A faculty advisor is also available to each undergraduate class for further academic program planning.

Program Goals for Undergraduate Programs
The goal of the computer science undergraduate program is to prepare future generations of computer professionals for long-term careers in research, technical development, and applications. Graduates of the B.S. program who wish to seek immediate employment are prepared for a wide range of computer science positions in industry and government. Outstanding graduates interested in highly technical careers, research, and/or academia, might consider furthering their education in graduate school.

The primary computer science departmental emphasis is on problem solving using computer program design, analysis and implementation, with both a theoretical foundation and a practical component.

Program Outcomes for Undergraduate Programs
The program enables students to achieve, by the time of graduation:
1. An ability to apply knowledge of computing and mathematics appropriate to computer science.
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, and social responsibilities.
6. An ability to communicate effectively.
7. An ability to analyze the impact of computing on individuals, organizations, and society, including ethical, legal, security, and global policy issues.
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.
10. An ability to apply mathematical foundations, algorithmic principles, and computer science theory in the modeling and design of computer-based systems in a way that demonstrates comprehension of the tradeoffs involved in design choices.
11. An ability to apply design and development principles in the construction of software systems of varying complexity.

Undergraduate Program
Bachelor of Science—Computer Science
A minimum of 184 units is required for graduation. A complete list of requirements for the major can be found on page 50. Schedules should be planned to meet both General Education and major requirements.
Students with no previous programming background should take CMPSC 8 before taking CMPSC 16. CMPSC 8 is not included in the list of preparation for the major course but may be counted as a free elective.

Bachelor of Science—Computer Engineering
This major is offered jointly by the Department of Computer Science and the Department of Electrical and Computer Engineering. For information about this major, see page 25.

Computer Science Courses
LOWER DIVISION
8. Introduction to Computer Science
(4) KHARITONOVA, MIRZA, MATNI
Not open for credit to students who have completed Computer Science 16 or Engineering 3.
Prerequisite: CMPSC 5AA-ZZ.
Introduction to computer program development for students with little to no programming experience. Basic programming concepts, variables and expressions, data and control structures, algorithms, debugging, program design, and documentation.

16. Problem Solving with Computers
(4) KHARITONOVA, MIRZA
Prerequisite: Math 3A with a grade of C or better
(may be taken concurrently).
and methods for assessing learning. Students gain experience working one-on-one with students, fostering positive learning environments, and providing feedback on student work. Students who successfully complete this course will earn units by serving as an apprentice undergraduate learning assistant.

110. Introduction to Research in Computer Science

Prerequisite: Computer Science 40 and Computer Science 32; consent of instructor.

- Defining a CS research problem, finding and reading technical papers, oral communication, technical writing, and independent learning. Course participants work in teams as they apprentice with a CS research group to propose an original research problem and write a research proposal.

111. Introduction to Computational Science

Prerequisites: Mathematics 4B with a grade of C or better; Mathematics 6A with a grade of C or better; Computer Science 24 with a grade of C or better.

- Not open for credit to students who have completed Computer Science 110A.
- Introduction to the numerical algorithms that form the foundations of data science, machine learning, and computational science and engineering. Matrix computation, linear equation systems, eigenvalue and singular value decompositions, numerical optimization. The inferred use of mathematical software environments and libraries, such as python/numpy/scipy.

130A. Data Structures and Algorithms I

Prerequisites: Computer Science 40 with a grade of C or better; Computer Science 32 with a grade of C or better; PSTAT 120A or ECE 139; open to computer science, computer engineering, and electrical engineering majors only.

- Data structures and applications with proofs of correctness and analysis. Hash tables, priority queues (heaps); balanced search trees. Graph traversal techniques and their applications. Graph traversal techniques and their applications.

130B. Data Structures and Algorithms II

Prerequisites: Computer Science 130A.

- Design and analysis of computer algorithms. Correctness proofs and solution of recurrence relations. Design techniques, divide and conquer, greedy strategies, dynamic programming. Applications of techniques to problems from different disciplines. NP-complete problems.

138. Automata and Formal Languages

Prerequisite: Computer Science 40 with a grade of C or better; open to computer science and computer engineering majors only.

- Formal languages; finite automata and regular expressions; properties of regular languages; pushdown automata and context-free grammars; properties of context-free languages; introduction to computability and unsolvability. Introduction to Turing machines and computational complexity.

140. Parallel Scientific Computing

Prerequisite: Mathematics 4B with a grade of C or better; Mathematics 6A with a grade of C or better; Computer Science 130A.

- Not open for credit to students who have completed Computer Science 110B.
- Fundamentals of high performance computing and parallel algorithm design for numerical computation. Topics include parallel architecture and clusters, parallel programming with message-passing libraries and threads, program parallelization methodologies, parallel performance evaluation and optimization, parallel numerical algorithms and applications with different performance trade-offs.

148. Computer Science Project

Prerequisite: Computer Science 32 with a grade of C or better; open to Computer Science majors only.

- Not open for credit to students who have completed Computer Science 48 with a grade of C or better.
- CMPSC 148 is a legal repeat of CMPSC 48.
- Team-based project development. Topics include software engineering and professional development practices, interface design, advanced library support; techniques for team oriented design and development, testing and test driven development, and software reliability and robustness. Students present and demonstrate final projects.

153A. Hardware/Software Interface

Prerequisite: Upper-division standing in computer science, computer engineering, or electrical engineering majors only.

- Same course as ECE 153A.
- Issues in interfacing computing systems and software to practical I/O interfaces. Rapid response, real-time events and management of tasks, thread, and scheduling required for efficient design of embedded software and systems is discussed. Techniques for highly constrained systems.

154. Computer Architecture

Prerequisite: Computer Science 32 with a grade of C or better, and Computer Science 64 with a grade of C or better.

- Not open for credit to students who have received credit for ECE 154, ECE 154A, or ECE 154B.
- Introduction to the architecture of computer systems. Topics include: central processing units, memory systems, channels and controllers, peripheral devices, interrupt systems, software versus hardware trade-offs.

156. Advanced Applications Programming

Prerequisite: Computer Science 48 and 32 with a grade of C or better; open to computer science and computer engineering majors only.

- Not open for credit to students who have completed Computer Science 56 with a grade of C or better.
- CMPSC 156 is a legal repeat of CMPSC 56.
- Not open for credit to students who have completed Computer Science 20.
- Advanced application programming using a high-level, virtual-machine-based language. Topics include generic programming, exception handling, automatic memory management, and application development, management, and maintenance tools, third-party library use, version control, software testing, issue tracking, code review, and working with legacy code.

160. Translation of Programming Languages

Prerequisite: Computer Science 64 or Electrical Engineering 154 or Electrical Engineering 154A; Computer Science 130A; and Computer Science 138; open to computer science and computer engineering majors only.

- Study of the structure of compilers. Topics include: lexical analysis; syntax analysis including LL and LR parsers; type checking; run-time environments; intermediate code generation; and compiler-construction tools.

162. Programming Languages

Prerequisite: Computer Science 32 and Computer Science 138; open to computer science and computer engineering majors only.

- Concepts of programming languages: scopes, parameter passing, storage management; control flow, exception handling; encapsulation and modularization mechanisms; reusability through genericity and inheritance; type systems, programming paradigms (imperative, object-oriented, functional, and others).

Emerging programming languages and their development infrastructures.

165A. Artificial Intelligence

Prerequisite: Computer Science 130A.

- Introduction to the field of artificial intelligence, which seeks to understand and build intelligent computational systems. Topics include intelligent agents, problem solving and heuristic search, knowledge representation and reasoning, uncertainty and probabilistic reasoning, machine learning, reinforcement learning, and responsible AI.

165B. Machine Learning

Prerequisite: Computer Science 130A (the ‘recommended preparation’ should be on the next line and not italicized). Recommended preparation: Computer Science 111.

- Covers the most important techniques of machine learning (ML) and includes discussions of: well-posed learning problems; artificial neural networks; concept learning and general to specific ordering; decision tree learning; genetic algorithms; Bayesian learning; analytical learning; and others.

170. Operating Systems

Prerequisite: Computer Science 130A; and, Computer Science 154 or ECE 154 (may be taken concurrently); open to computer science, computer engineering or electrical engineering majors only.

- Basic concepts of operating systems. The notion of a process; inter-process communication and synchronization; input-output, file systems, memory management.

171. Distributed Systems

Prerequisite: Computer Science 130A.

- Not open for credit to students who have completed ECE 151.
- Distributed systems architecture, distributed programming, network of computers, message passing, remote procedure calls, group communication, naming and membership problems, asynchrony, logical time, consistency, fault-tolerance, and recovery.

172. Software Engineering

Prerequisite: Computer Science 130A; computer science or computer engineering majors only, or by consent of department.

- Software engineering is concerned with long-term, large-scale programming projects. Software management, cost estimates, problem specification and analysis, system design techniques, system testing and performance evaluation, and system maintenance. Students will design, manage, and implement a medium-sized project.

174A. Fundamentals of Database Systems

Prerequisite: Computer Science 130A.

- Recommended Preparation: Students are strongly encouraged to complete Computer Science 56 or Computer Science 156 prior to enrolling in Computer Science 174A.
- Database system architectures, relational data model, relational algebra, relational calculus, SQL, QBE, query processing, integrity constraints (key constraints, referential integrity), database design, ER and object-oriented data model, functional dependencies, lossless join and dependency preserving decompositions, Boyce-Codd and Third Normal Forms.

174B. Design and Implementation Techniques of Database Systems

Prerequisite: Computer Science 130B.

- Recommended Preparation: Students are strongly encouraged to complete Computer Science 56 or Computer Science 156 prior to enrolling in Computer Science 174B.
181. Introduction to Computer Vision

Prerequisite: Upper-division standing. Same course as ECE 181.
Not open for credit to students who have completed ECE/CMPS 181B with a grade of C or better.
ECE/CMPS 181 is a legal repeat of ECE/CMPS 181B.
Overview of computer vision problems and techniques for analyzing the content images and video.
Topics include image formation, edge detection, image segmentation, pattern recognition, texture analysis,
optical flow, stereo vision, shape representation and recovery techniques, issues in object recognition,
and case studies of practical vision systems.

184. Mobile Application Development

Prerequisite: Computer Science 56 or Computer Science 130A.
An introduction to programming mobile computing devices.
Students will learn about and study the shift in software development from desktop to
device applications. Topics will include software engineering and design practices, advances in
programming practice, and support tools for mobile application development and testing.
Students will develop and deploy mobile applications as part of their course work.

185. Human-Computer Interaction

Prerequisite: Upper-division standing in computer science,
computer engineering, or electrical engineering majors.
Recommended preparation: Students are strongly encouraged to complete Computer Science 56 or
Computer Science 156 prior to enrolling in Computer Science 185. Proficiency in the Java/C++ programming
language, some experience with user interface programming.
The study of human-computer interaction enables system architects to design useful, efficient, and en-
joyable computer interfaces. This course teaches the theory, design guidelines, programming practices,
and evaluation procedures behind effective human interaction with computers.

189A. Senior Computer Systems Project

Prerequisite: Computer Science 48 or 56 or 148 or
156 or 172; Senior standing in computer science or computer engineering.
Not open for credit to students who have completed
ECE 189A.
Student groups design a significant computer-based project. Multiple groups may cooperate
independently; interaction among groups is via interface specifications and informal meetings. Project for
follow-up course may be different.

189B. Senior Computer Systems Project

Prerequisite: CMPSC 189A; Senior standing in computer science or computer engineering.
Not open for credit to students who have completed
ECE 189A or ECE 189B.
Student groups design a significant computer-based project. Multiple groups may cooperate
toward one large project. Each group works independently; interaction among groups is via interface
specifications and informal meetings. Project for course may be different from that in first course.

190AA-ZZ. Special Topics in Computer Science

Prerequisite: consent of instructor.
May be repeated with consent of the department chair.

Courses provide for the study of topics of current interest in computer science: A. Foundations; B.
Software Systems; C. Programming languages and software engineering; D. Information management;
E. Architecture; F. Networking; G. Security; H. Scientific computing; I. Intelligent and interactive systems;
N. General

192. Projects in Computer Science

Prerequisite: consent of instructor.
Students must have a minimum 3.0 GPA.
May be repeated with consent of chair.
Projects in computer science for advanced undergraduate students.

193. Internship in Industry

Prerequisites: consent of instructor and department chair.
Not more than 4 units per quarter; may not be used as a field elective and may not be applied to
to science electives. May be repeated with faculty approval.
Projects in computer science for advanced undergraduate students.

196. Undergraduate Research

Prerequisite: Students must: (1) have attained upper-
division standing (2) have a minimum 3.0 grade-
point average for preceding three quarters, (3) have consent of instructor.
May be repeated for up to 12 units. No more than
4 units may be applied to departmental electives.
Research opportunities for undergraduate students. Students will be expected to give regular oral
presentations, actively participate in a weekly seminar, and prepare at least one written report on
their research.

196B. Undergraduate Research

Prerequisite: Students must (1) have taken 4 letter-
graded units of CMPSC 196, (2) have consent of instructor.
Designed for majors. May be repeated for up to
12 units. No more than 4 units may be applied to
departmental electives.
Advanced research for undergraduate students, by petition after completing a minimum of 4 units of
CMPSC 196 for a letter grade. The student will propose a specific research project and make a public
presentation of final results. Evaluation and grade will be based on feedback from the research faculty
advisor and one other faculty member.

199. Independent Studies in Computer Science

Prerequisites: upper-division standing; must have completed at least two upper-division courses in
computer science.
Must have a minimum 3.0 grade-point average for the preceding three quarters. May be repeated with
consent of chair. Students are limited to 5 units per quarter and 30 units total in all 198/199 courses com-
bined. May not be used for credit towards the major.
Independent study in computer science for advanced students.

GRADUATE COURSES

Graduate courses for this major can be found in the UCSB General Catalog.
Electrical & Computer Engineering

Department of Electrical and Computer Engineering, Building 380, Room 101; (805) 893-2269 or (805) 893-3821
www.ece.ucsb.edu
Chair: B.S. Manjunath
Vice Chair: Luke Theogarajan

Faculty

Rod C. Alferness, Ph.D., University of Michigan, Distinguished Professor and Dean (integrated optoelectronics, optical switching technology and switched optical networks)

Mahnoosh Alizadeh, Ph.D., UC Davis, Assistant Professor (Smart power grids, demand response and renewable energy integration, cyber-physical systems, network control)

Kaustaw Banerjee, Ph.D., UC Berkeley, Professor (high performance VLSI and mixed signal system-on-chip designs and their design automation methods; single electron transistors; 3D and optoelectronic integration)

Ilan Ben-Yaacov, Ph.D., UC Santa Barbara, Lecturer SOE (semiconductor device physics and electronic devices, power electronics, engineering education)

Daniel J. Blumenthal, Ph.D., University of Colorado at Boulder, Professor (fiber-optic networks, wavelength and subcarrier division multiplexing, photonic packet switching, signal processing in semiconductor optical devices, wavelength conversion, microwave photonics)

John E. Bowers, Ph.D., Stanford University, Distinguished Professor (high-speed photonic and electronic devices and integrated circuits, fiber optic communication, semiconductors, laser physics and mode-locking phenomena, compound semiconductor materials and processing)

Forrest D. Brewer, Ph.D., University of Illinois at Urbana-Champaign, Professor (VLSI and computer system design automation, theory of design and design representations, symbolic techniques in high level synthesis)

James Buckwalter, Ph.D., California Institute of Technology, Professor (RF and mixed-signal CMOS integrated circuits, high-speed communications systems)

Katie A. Byl, Ph.D., Massachusetts Institute of Technology, Associate Professor (robotics, autonomous systems, dynamics, control, manipulation, locomotion, machine learning)

Kerem Camsari, Ph.D., Purdue University, Assistant Professor (Nanoelectronics, Spintronics, Emerging Technologies for Computing, Digital & Mixed-signal VLSI, Neuromorphic & Probabilistic Computing, Quantum Computing, Hardware Acceleration)

Shivkumar Chandrasekaran, Ph.D., Yale University, Professor (numerical analysis, numerical linear algebra, scientific computation)

Nadir Dagli, Ph.D., Massachusetts Institute of Technology, Professor (design, fabrication, and modeling of photonic integrated circuits, ultrafast electrooptic modulators, solid state microwave and millimeter wave devices; experimental study of ballistic transport in quantum confined structures)

Steven P. DenBaars, Ph.D., University of Southern California, Distinguished Professor (metalorganic vapor phase epitaxy, optoelectronic materials, compound semiconductors, indium phosphide and gallium nitride, photonic devices) *1

Jerry Gibson, Ph.D., Southern Methodist University, Distinguished Professor (digital signal processing, data, speech, image and video compression, and communications via multi-use networks, data embedding, adaptive filtering)

Joao Hespanha, Ph.D., Yale University, Professor (hybrid and switched systems, multi-agent control systems, game theory, optimization, distributed control over communication networks also known as networked control systems, coordination and control of groups of unmanned air vehicles, the use of vision in feedback control, network security)

Yogananda Isukapalli, Ph.D., UC San Diego, Lecturer SOE (Low power hardware design, Multi-antenna wireless communications, Transmit beam forming, Vector quantization, Performance analysis of communication systems)


Jonathan Klamkin, Ph.D., UC Santa Barbara, Professor (Integrated Photonics, Silicon Photonics, Optical Communications, Nonophotonics, Microwave Photonics, Compound Semiconductors, Photonic Integration Techniques, Electronic-photonic Integration)

Hua Lee, Ph.D., UC Santa Barbara, Distinguished Professor (image system optimization, high-performance image formation algorithms, synthetic-aperture radar and sonar systems, acoustic microscopy, microwave nondestructive evaluation, dynamic vision systems)

Peng Li, Ph.D., Carnegie Mellon University, Professor (Integrated circuits and systems, learning algorithms and circuits for braininspired computing, electronic design automation, computational brain modeling, hardware machine learning systems)

Upamanyu Madhow, Ph.D., University of Illinois, Distinguished Professor (spread-spectrum and multiple-access communications, space-time coding, and internet protocols)

B.S. Manjunath, Ph.D., University of Southern California, Distinguished Professor (image processing, computer vision, pattern recognition, neural networks, learning algorithms, content based search in multimedia databases)

Jason R. Marden, Ph.D., UC Los Angeles, Professor (Feedback Control and Systems Theory; Game Theoretic Methods for Coordination of Large Scale Distributed Systems; Application to Distributed Traffic Routing, Dynamic Resource Allocation, Queueing Systems, and Sensor Networks)

Umesh Mishra, Ph.D., Cornell University, Distinguished Professor (high-speed transistors, semiconductor device physics, quantum electronics, wide band gap materials and devices, design and fabrication of millimeter-wave devices, in situ processing and integration techniques)

Galan Moody, Ph.D., University of Colorado-Boulder, Assistant Professor (Quantum Photonics; Nanoscale Quantum Systems and Devices including Quantum Dots and 2D Materials; Quantum Light Generation, Manipulation, and Detection; Hybrid Quantum Systems; Valleytronics)

Yasamin Mostofi, Ph.D., Stanford University, Professor (RF sensing, robotics,
wireless systems, multi-agent systems, mobile sensor networks)

Christopher Palmstrom, Ph.D., Leeds University, Distinguished Professor (atomic level control of interfacial phenomena, in-situ STM, surface and thin film analysis, metallization of semiconductors, dissimilar materials epitaxial growth, molecular beam and chemical beam epitaxial growth of metallic compounds) *1

Behrooz Parhami, Ph.D., UC Los Angeles, Professor (parallel architectures and algorithms, computer arithmetic, computer design, dependable and fault-tolerant computing)

Ramtin Pedarsani, Ph.D., UC Berkeley, Assistant Professor (information and coding theory, machine learning, applied probability, network control, transportation systems, game theory)

Mark J.W. Rodwell, Ph.D., Stanford University, Distinguished Professor (nm and THz electronics: THz Transistors, nm VLSI Transistors VLSI, 100-1000GHz RF/Wireless ICs, beyond-5G-wireless, ICs for fast Optical Fiber Communication)

Kenneth Rose, Ph.D., California Institute of Technology, Distinguished Professor, (information theory, source and channel coding, image coding, communications, pattern recognition)

Loai Salem, PhD, UC San Diego, Assistant Professor (power management integrated circuits, power electronics using new devices/passives, low-power mixed-signal circuits)

Clint Schow, PhD, University of Texas, Austin, Professor (optoelectronic/electronic co-design and integration, equalization techniques for high-speed optical links, photonic switching, optoelectronic devices, integrated transceiver packaging)

Jon A. Schuller, Ph.D., Stanford University, Associate Professor (nanophotonics, organic optoelectronics, plasmonics, metamaterials)

Pradeep Sen, Ph.D., Stanford University, Professor (computer graphics and imaging)

Spencer L. Smith, PhD, UC Los Angeles, Associate Professor (neuroengineering, neuroscience, optics, imaging, visual processing neuronal circuitry)

Dmitri B. Strukov, Ph.D., Stony Brook University, Professor (hybrid circuits, nanoelectronics, resistance switching devices, memristors, digital memories, programmable circuits, bio-inspired computing)

Andrew Teel, Ph.D., UC Berkeley, Distinguished Professor (control design and analysis for nonlinear dynamical systems, input-output methods, actuator nonlinearities, applications to aerospace problems)

Luke Theogarajan, Ph.D., Massachusetts Institute of Technology, Professor (low-power analog VLSI, biomimetic nanosystems, neural prostheses, biosensors, block co-polymer synthesis, self-assembly, and microfabrication)

Yon Visell, PhD, McGill University, Associate Professor (Haptics, robotics, sensors, virtual reality, interactive technologies) Joint Appointment: MAT

Li-C. Wang, Ph.D., University of Texas, Austin, Professor (Artificial Intelligence for Design and Test, Data Analysis, Machine Learning)

Robert York, Ph.D., Cornell University, Distinguished Professor (high-power/high-frequency devices and circuits, quasi-optics, antennas, electromagnetic theory, nonlinear circuits and dynamics, microwave photonics)

Zheng Zhang, Ph.D., Massachusetts Institute of Technology, Assistant Professor (Photonic, Electronic, and MEMS Design Automation; Modeling and Verification of Robots & Autonomous Driving; High-Dimensional Data Analysis and Machine Learning; Magnetic Resonance Imaging (MRI))

Emeriti Faculty

Steven E. Butner, Ph.D., Stanford University, Professor (computer architecture, VLSI design of CMOS and gallium-arsenide ICs with emphasis on distributed organizations and fault-tolerant structures)

Kwang-Ting (Tim) Cheng, Ph.D., UC Berkeley, Distinguished Professor (design automation, VLSI testing, desig synthesis, design verification, algorithms)

Larry A. Coldren, Ph.D., Stanford University, Distinguished Professor in Optoelectronics and Sensors, Director of Optoelectronics Technology Center (semiconductor integrated optoelectronics, vertical-cavity lasers, widely-tunable lasers, optical fiber communication, growth and planar processing techniques) *1

Jorge R. Fontana, Ph.D., Stanford University, Professor Emeritus (quantum electronics, particularly lasers, interaction with charged particles)

Allen Gersho, Ph.D., Cornell University, Professor Emeritus, Director of Center for Information Processing Research (speech, audio, image, and video compression, quantization and signal compression techniques, and speech processing)

Arthur C. Gossard, Ph.D., UC Berkeley, Professor Emeritus, (epitaxial crystal growth, artificially structured materials, semiconductor structures for optical and electronic devices, quantum confinement structures) *1

Glenn R. Heidbreder, D. Eng., Yale University, Professor Emeritus (communication theory, signal processing in radar and digital communication systems; digital image processing)

Ronald Ilitis, Ph.D., UC San Diego, Professor (digital spread spectrum communications, spectral estimation and adaptive filtering)

Petar V. Kokotovic, Ph.D., USSR Academy of Sciences, Professor Emeritus, Director of Center for Control Engineering and Computation, Director of Center for Robust Nonlinear Control of Aeroengines (sensitivity analysis, singular perturbations, large-scale systems, non-linear systems, adaptive control, automotive and jet engine control)

Herbert Kroemer, Dr. rer. nat., University of Göttingen, Donald W. Whittier Professor in Electrical Engineering, 2000 Physics Nobel Laureate (general solid-state and device physics, heterostructures, molecular beam epitaxy, compound semiconductor materials and devices, superconductivity) *1

Stephen I. Long, Ph.D., Cornell University, Professor Emeritus, (semiconductor devices and integrated circuits for high speed digital and RF analog applications)

Malgorzata Marek-Sadowska, Ph.D., Technical University of Warsaw, Poland, Distinguished Professor (design automation, computer-aided design, integrated circuit layout, logic synthesis)

George L. Matthaei, Ph.D., Stanford University, Professor Emeritus (circuit design techniques for passive and active microwave, millimeter-wave and optical integrated circuits, circuit problems of high-speed digital integrated circuits)

P. Michael Melliar-Smith, Ph.D., University of Cambridge, Professor (fault tolerance, formal specification and verification, distributed systems, communication networks and protocols, asynchronous systems)

James L. Merz, Ph.D., Harvard University, Professor Emeritus (optical properties of semiconductors, including guided-wave and integrated optical devices,
Under the direction of the Associate Dean for Undergraduate Studies, academic advising services are jointly provided by advisors in the College of Engineering, as well as advisors in the department. Students who plan to change to a major in the department should consult the ECE student office. Departmental faculty advisors are assigned to students to assist them in choosing senior elective courses. Counseling is provided to graduate students through the ECE graduate advisor. Individual faculty members are also available for help in academic planning.

Mission Statement

The Department of Electrical and Computer Engineering seeks to provide a comprehensive, rigorous and accredited educational program for the graduates of California's high schools and for postgraduate students, both domestic and international. The department has a dual mission:

• Education: We will develop and produce excellent electrical and computer engineers who will support the high-tech economy of California and the nation. This mission requires that we offer a balanced and timely education that includes not only strength in the fundamental principles but also experience with the practical skills that are needed to contribute to the complex technological infrastructure of our society. This approach will enable each of our graduates to continue learning throughout an extended career.

• Research: We will develop relevant and innovative science and technology through our research that addresses the needs of industry, government and the scientific community. This technology can be transferred through our graduates, through industrial affiliations, and through publications and presentations.

We provide a faculty that is committed to education and research, is accessible to students, and is highly qualified in their areas of expertise.

Educational Objectives

The educational objectives of the Electrical Engineering Program identify what we hope that our graduates will accomplish within a few years after graduation.

1. We expect our graduates to make positive contributions to society in fields including, but not limited to, engineering.

2. We expect our graduates to have acquired the ability to be flexible and
adaptable, showing that their educational background has given them the foundation needed to remain effective, take on new responsibilities and assume leadership roles.

3. We expect some of our graduates to pursue their formal education further, including graduate study for master's and doctoral degrees.

Student Outcomes
Upon graduation, students from the EE program at UCSB are expected to have:

1. An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.
2. An ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors.
3. An ability to communicate effectively with a range of audiences.
4. An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgements, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts.
5. An ability to function effectively on a team whose members together create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives.
6. An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering to draw conclusions.
7. An ability to acquire and apply new knowledge as needed, using appropriate learning strategies.

Undergraduate Program

Bachelor of Science—Electrical Engineering
A minimum of 189 units is required for graduation. A complete list of requirements for the major can be found on page 52. Schedules should be planned to meet both General Education and major requirements.

The department academic advisor can suggest a recommended study plan for electrical engineering freshmen and sophomores. Each student is assigned a departmental faculty advisor who must be consulted in planning the junior and senior year programs.

The required 32 units (8 courses) of departmental electives are taken primarily in the senior year, and they permit students to develop depth in specialty areas of their choice. The 32 units of departmental electives must include at least 2 sequences, one of which must be an approved EE Senior Capstone Design/Project course sequence. A student's elective course program must be approved by a departmental faculty advisor. The advisor will check the program to ensure satisfaction of the departmental requirements. A wide variety of elective programs will be considered acceptable.

Three matters should be noted:

1. Students who fail to attain a grade-point average of at least 2.0 in the major may be denied the privilege of continuing in the major, (2) a large majority of electrical and computer engineering courses have prerequisites which must be completed successfully. Successful completion of prerequisite courses means receiving a grade of C- or better in prerequisite courses except for Mathematics 3A-B, Mathematics 4A-B and Mathematics 6A and 6B which require a grade of C or better to apply these courses as prerequisites, (3) courses required for the pre-major or major, inside or outside of the Department of Electrical Engineering, cannot be taken for the passed/not passed grading option. They must be taken for letter grades.

Bachelor of Science—Computer Engineering

This major is offered jointly by the Department of Computer Science and the Department of Electrical and Computer Engineering. For information about this major, see page 25.

Electrical & Computer Engineering Courses
Many of the ECE courses are restricted to ECE majors only. Instructor and quarter offered are subject to change.

LOWER DIVISION

1A. Computer Engineering Seminar
(1) STAFF
Prerequisite: Open to computer engineering majors only. Seminar, 1 hour
Introductory seminar to expose students to a broad range of topics in Computer Engineering.

1B. Ten Puzzling Problems in Computer Engineering
(1) PARHAMI
Prerequisite: Open to pre-computer engineering and computer engineering majors only.
Not open for credit for those who have taken ECE 1
Gaining familiarity with, and motivation to study, the field of computer engineering, through puzzle-like problems that represent a range of challenges facing computer engineers in their daily problem-solving efforts and at the frontiers of research.

3. Introduction to Electrical Engineering
(4) STAFF
Prerequisites: Open to EE majors only. Lecture, 3 hours; laboratory, 2 hours
Introduction to fundamental design problems in Electrical Engineering through programming in Python. Includes basics of software engineering, algorithm design, data structures, with design problems derived from signals systems. Specific areas will include 1-D and 2-D signal processing, basic transforms and applications.

5. Introduction to Electrical & Computer Engineering
(4) STAFF
Prerequisite: Open only to Electrical Engineering and Computer Engineering majors. Lecture, 2 hours; Laboratory: 3 hours
Aims at exposing freshmen students to the different sub-fields within Electric and Computer Engineering. Composed of lectures by different faculty members and a weekly laboratory based on projects that are executed using the Arduino environment.

10A. Foundations of Analog and Digital Circuits & Systems
(3) STAFF
Prerequisite: Mathematics 2A or 3A or 3AH or 3AH-B, and Mathematics 3C or 4A or 4AI with a minimum grade of C; and, Math 11B or 11L or Math 5A with a minimum grade of C (may be taken concurrently); Physics 3 or 23 (may be taken concurrently); only open to electrical engineering and computer engineering majors. Lecture: 3 hours
Not open for credit for those who have received a C- or higher in ECE 2A.

The objective of the course is to establish the foundations of analog and digital circuits. The course will introduce the student to the power of abstraction, resistive networks, network analysis, nonlinear analysis and the digital abstraction.

10A-L. Foundations of Analog and Digital Circuits and Systems Lab
(2) STAFF
Prerequisite: ECE 10A (may be taken concurrently) with a C- or better grade. Laboratory: 4 hours
Not open for credit for those who have received a C- or higher in ECE 2A.

The goal of 10AL is to provide the student with a hands-on application of the concepts discussed in ECE 10A. The lab will introduce the use of microcontrollers as a data acquisition system, network analysis, resistors, nonlinear analysis and digital abstraction.

10B. Foundations of Analog and Digital Circuits and Systems
(3) STAFF
Prerequisite: ECE 10A with a C- or better grade. Lecture, 3 hours
Not open for credit for those who have received a C- or higher in ECE 2B.

The objective of the course is to introduce the MOSFET both as a simple digital switch and as controlled current source for analog design. The course will cover basic digital design, small-signal analysis, charge storage elements and operational amplifiers. (W)

10B-L. Foundations of Analog and Digital Circuits and Systems Lab
(2) STAFF
Prerequisite: ECE 10B (may be taken concurrently) with a C- or better grade. Laboratory: 4 hours
Not open for credit for those who have received a C- or higher in ECE 2B.

The goal of 10BL is to provide the student with a hands-on application of the concepts discussed in ECE 10B. The lab will utilize the microcontroller to introduce students to the understanding of datasheets for both digital and analog circuits, single-stage
amplifier design and basic instrumentation.

10C. Foundations of Analog and Digital Circuits and Systems
(3) STAFF
Prerequisite: ECE 10B with a C- or better grade.
Lecture: 3 hours
Not open for credit for those who have received a 
C- or higher in ECE 2C.
The objective of the course is to introduce the 
student to the basics of transient analysis. The course 
will energy and power dissipation in digital circuits, 
first-order and second-order linear time invariant 
circuits, sinusoidal steady state, impedance representa-
tion, feedback and resonance. (S)

10CL. Foundations of Analog and Digital 
Circuits and Systems Lab
(2) STAFF
Prerequisite: ECE 10C (may be taken concurrently) 
with a C- grade or better. Laboratory: 4 hours
Not open for credit for those who have received a 
C- or higher in ECE 2C.
The goal of 10CL is to provide the student with a 
hands-on application of the concepts discussed in 
ECE 10C. The lab will utilize the microcontroller 
to introduce students to the understanding of propaga-
tion delay in digital circuits and the resulting power 
dissipation, first order linear networks, second order 
linear networks, sinusoidal steady-state, impedance 
analysis and op-amp circuits.

15A. Fundamentals of Logic Design
(4) ZHANG
Prerequisites: Open to electrical engineering, computer 
engineering, and pre-computer engineering majors 
only.
Not open for credit to students who have com-
pleted ECE 15. Lecture, 3 hours; discussion, 1 hour.
Boolean algebra, logic of propositions, minterm 
and maxterm expansions, Karnaugh maps, Quine-Mc 
Cluskey methods, multi-level circuits, combinational 
circuit design and simulation, multiplexers, decoders, 
programmable logic devices.

92. Projects in Electrical and Computer 
 Engineering
(4) STAFF
Prerequisite: Consent of instructor; for Electrical Engi-
neering and Computer Engineering majors only
Projects in electrical and computer engineering for 
advanced undergraduate students.

94A-ZZ. Group Studies in Electrical 
and Computer Engineering
(1-4) STAFF
Prerequisite: consent of instructor.
Group studies intended for small number of ad-
vanced students who share an interest in a topic not 
included in the regular departmental curriculum.

96. Undergraduate Research
(2-4) STAFF
Prerequisite: Consent of instructor. Must have a 3.00 
GPA. May be repeated for up to 12 units.
Research opportunities for undergraduate 
students. Students will be expected to give regular 
oral presentations, actively participate in a weekly 
seminar, and prepare at least one written report on 
their research.

UPPER DIVISION

120A. Integrated Circuit Design and Fabrica-
tion
(4) BEN-YAACOV
Prerequisite: ECE 132 with a minimum grade of C-.
Lecture: 3 hours; Laboratory: 3 hours
Not open for credit for those who have taken ECE 
124B.
Theory, fabrication, and characterization of solid 
state devices including P-N junctions, capacitors, 
bipolar and MOS devices. Devices are fabricated 
using modern VLSI processing techniques including 
lithography, oxidation, diffusion, and evaporation. 
Physics and performance of processing steps are 
discussed and analyzed.

120B. Integrated Circuit Design and Fabrica-
tion (4) BEN-YAACOV
Prerequisite: Either ECE 120A or ECE 124B with a 
minimum grade of C- or better in each of the courses.
Lecture: 3 hours; Laboratory: 3 hours
Not open for credit to those who have taken ECE 
124C.
Design, simulation, fabrication, and characterization 
of NMOS integrated circuits. Circuit design 
and layout is performed using commercial layout 
software. Circuits are fabricated using modern VLSI 
processing techniques. Transistor and discrete device 
transistor models are analyzed.

122A. VLSI Principles
(4) BANERJEE
Prerequisite: ECE 152A with a minimum grade of C-.
Lecture: 3 hours; Laboratory: 3 hours
Not open for credit to those who have taken ECE 
124A or ECE 123.
Introduction to CMOS digital VLSI design: CMOS 
deVICES and manufacturing technology; transistor 
level design of static and dynamic logic gates and 
components and interconnections; circuit character-
ization: delay, noise margins, and power dissipation; 
combinational and sequential circuits; arithmetic 
operations and memories.

122B. VLSI Architecture and Design
(4) BREWER
Prerequisite: ECE 124A or ECE 123 or ECE 122A with 
a minimum grade of C-.
Lecture: 3 hours; Laboratory: 2 hours
Not open for credit to those who have taken ECE 
124D.
Practical issues in VLSI circuit design, pad-pin 
limitations, clocking and interlocking standards, electriz-
ity packaging for high-speed and high-performance design. 
On-chip noise and crosstalk, clock 
and power distribution, architectural and circuit design 
constraints, interconnection limits and transmission 
line effects.

123. High-Performance Digital Circuit Design
(4) THEOGARAJAN
Prerequisite: ECE 10A-B-C and ECE 10AL-CL or 
ECE 2A-B-C with a minimum grade of C- in each of 
those courses; open to both electrical engineering 
and computer engineering majors only.
Not open for credit to those who have taken ECE 
124A or ECE 122A.
Introduction to high-performance digital circuit 
design techniques. Basics of device physics including 
deep submicron effects; device sizing and logical 
effort; Circuit design styles; clocking & timing issues; 
memory & datapath design; Low-power design; VLSI 
design flows and associated EDA tools

125. High Speed Digital Integrated Circuit 
 Design
(4) BANERJEE
Prerequisite: ECE 124A or 137A with a minimum 
grade of C- in either. Lecture, 4 hours.
Advanced digital VLSI design: CMOS scaling, na-
noscale issues including variability, thermal manage-
ment, interconnects, reliability; non-clocked, clocked 
and self-timed logic gates; clocked storage elements; 
high-speed components, PLLs and DLLs; clock and 
power distribution; memory systems; signaling and 
I/O design; low-power design.

130A. Signal Analysis and Processing
(4) STAFF
Prerequisite: Mathematics 4B or 5A with a minimum 
grade of C; open to EE and computer engineering 
majors only. Lecture: 3 hours; Discussion: 2 hours.
Analysis of continuous-time signal systems in the 
time and frequency domains. Superposition 
and convolution. Bilateral and unilateral Laplace trans-
forms. Fourier series and Fourier transforms. Filtering, 
modulation, and feedback.

130B. Signal Analysis and Processing
(4) CHANDRASEKARAN
Prerequisite: ECE 130A with a grade of C- or better; 
open to EE and computer engineering majors only.
Lecture, 3 hours; discussion, 2 hours.
Analysis of discrete time linear systems in the 
time and frequency domains. Z transforms, Discrete 
Fourier transforms. Sampling. Transforms and aliasing.

130C. Signal Analysis and Processing 
and (4) CHANDRASEKARAN
Prerequisites: ECE 130A-B with a minimum grade of 
C- in both. Lecture, 2 hours; discussion, 2 hours.
Basic techniques for the analysis of linear models 
in electrical engineering. Gaussian elimination, 
vector spaces and linear equations, orthogonal, 
determinants, eigenvalues and eigenvectors, systems of 
linear differential equations, positive definite matri-
ces, singular value decomposition.

132. Introduction to Solid-State Electronic 
 Devices
(4) STAFF
Prerequisite: Physics 4 or 24 with a minimum grade of 
C-; Mathematics 4B or 5A with a minimum grade of 
C-; and, ECE 10A-B and ECE 10AL-CL or ECE 2A-B 
(may be taken concurrently) with a minimum grade of 
C- in each; open to EE and computer engineering 
majors only. Lecture: 3 hours; Discussion: 2 hours.
Electrons and holes in semiconductors; doping (P 
and N); state occupation statistics, transport proper-
ties of electrons and holes; P-N junction diodes; I-V, 
C-V, and switching properties of P-N junctions; intro-
duction of bipolar transistors, MOSFETs and JFETs.

134. Introduction to Fields and Waves
(4) DAGLI
Prerequisite: Physics 3 or 23 with a minimum grade of 
C-; Mathematics 4B or 4BI or 5A and Mathematics 5B 
or 6A or 6AI with a minimum grade of C in each; and 
Mathematics 5C or 6B with a minimum grade of C-; 
open to EE and computer engineering majors only 
Lecture: 3 hours; Discussion: 2 hours.
Introduction to applied electromagnetics and 
wave phenomena in high frequency electron circuits and 
systems. Waveon transmission lines, elements of electro-
statistics and magnetostatics and applica-
tions plane waves, examples and applications to RF, 
microwave, and optical systems.

135. Optical Fiber Communication
(4) DAGLI
Prerequisites: ECE 132 and 134 with a minimum grade of 
C- in both. Lecture, 3 hours; discussion, 1 hour.
Optical fiber as a transmission medium, dispersion 
and nonlinear effects in fiber transmission, fiber 
and semiconductor optical amplifiers and lasers, optical 
modulators, photo detectors, optical receivers, 
wavelength division multiplexing components, optical 
filters, basic transmission system analysis and design.

137A. Circuits and Electronics I
(4) RODWELL
Prerequisites: ECE 10A-B-C and ECE 10AL-CL or 
ECE 2A-B-C, 130A, and 132 all with a minimum grade of 
C- in all; open to EE majors only. Lecture, 3 hours; 
laboratory, 3 hours.
Analysis and design of single stage and multistage 
transistor circuits including biasing, gain, impedances 
and maximum signal levels.

137B. Circuits and Electronics II
(4) RODWELL
Prerequisites: ECE 10C and 10CL or ECE 2C and 
137A with a minimum grade of C- in both; open to 
EE majors only. Lecture, 3 hours; laboratory, 3 hours.
Analysis and design of single stage and multistage 
transistor circuits at low and high frequencies. 
Transient response. Analysis and design of feedback 
circuits. Stability criteria.

139. Probability and Statistics
(4) STAFF
Prerequisite: Open to Electrical Engineering, Com-
puter Engineering and pre-Computer Engineering 
majors only. Lecture, 3 hours; discussion, 2 hours.
Fundamentals of probability, conditional probabil-
ity, Bayes rule, random variables, functions of random 
variables, expectation and higher moments, Markov chains, hypothesis testing.

141A. Introduction To Nanoelectro-mechanical 
and Microelectromechanical Systems(NEMS/
**145A. Communication Electronics**

(5) ROODWELL
Prerequisites: ECE 137A-B with a minimum grade of C- in both. Lecture, 3 hours; laboratory, 6 hours. RF/Microwave circuits. Transistor, transmission-line, and passive element characteristics. Transmis-
sion-line theory and impedance matching. Amplifier design for maximum available gain. Amplifier stabil-
ity. Gain compression and power limits. Introduction to noise figure, and to intermodulation distortion.

Modern wireless communication standards. Cellular phone. Wireless LAN. Introduction to multi-
access techniques. Advanced modulation schemes. Interference and distortion. Modern transceiver archi-
tectures. Direct conversion vs. low IF vs. superhetero-
dyne. Sub-sampling receiver. Direct polar modulator. Frequency synthesis using PLL.

146A. Digital Communication Fundamentals

(5) MADHOW
Prerequisites: ECE 130A-B with a minimum grade of C-; open to EE majors only. Lecture: 3 hours; Labora-
tory: 6 hours
- Signal and channel models, with emphasis on wireless systems; digital modulation; demodulation basics; statistical modeling of noise, including review of probability theory and random variables.

146B. Communication Systems Design

(5) MADHOW
Prerequisites: ECE 130A-B and 146A with minimum grades of C-; open to EE majors only. Lecture: 3 hours; Laboratory: 6 hours
- Optimal demodulation, including signal space geometry; communication performance characteriza-
tion; advanced wireless communication techniques, including multi-antenna and multicarrier systems; other emerging frontiers in communications.

147A. Feedback Control Systems - Theory and Design

(5) TEEL
Prerequisites: ECE 130A-B with a minimum grade of C- in each; open to EE and computer engineering majors only. Lecture, 3 hours; laboratory, 6 hours.
- Feedback systems design, specifications in time and frequency domains. Analysis and synthesis of closed loop systems. Computer aided analysis and design.

147B. Digital Control Systems - Theory and Design

(5) BYL
Prerequisite: ECE 147A with a minimum grade of C-; open to EE and computer engineering majors only. Lecture, 3 hours; laboratory, 3 hours
- Analysis of sampled data feedback systems; state space description of linear systems; observability, controllability, pole assignment, state feedback, observers. Design of digital control systems. (W)

147C. Control System Design Project

(5) HESUVINH
Prerequisites: ECE 147A or ME 155B or ME 173 with a minimum grade of C-. Lecture, 3 hours; laboratory, 6 hours.
- Students are required to design, implement, and document a significant control systems project. The project is implemented in hardware or in high-fidelity numerical simulators. Lectures and laboratories cover special topics related to the practical implementation of control systems.

148. Applications of Signal Analysis and Processing

(4) LEE
Prerequisite: ECE 130A and 130B with a minimum grade of C- in both. Lecture: 3 hours; Discussion: 2 hours
- Recommended Preparation: concurrent enrollment in ECE 130C.
- A sequence of engineering applications of signal analysis and processing techniques; in communica-
tions, image processing, analog and digital filter design; signal detection and parameter estimation, holography and tomography, Fourier optics, and microwave and acoustic sensing.

149. Game Theory for Networked Systems

(4) MADSEN
Prerequisite: upper division standing or consent of instructor.
- An overview of game theory with an emphasis on application to multiagent systems. Game theory fo-
cuses on the study of systems that are comprised of interacting and possibly competing decision-making entities. Examples drawn from engineered, econom-
ic, and social systems.

150. Mobile Embedded Systems

(4) STAFF
Prerequisite: Proficiency in JAVA programming, and a C- in ECE 152A.
- Architectures of modern smartphones and their key hardware components including mobile ap-
lication processors, communications chips, display, touchscreens, graphics, memory, battery, GPS, and various sensors; the OS and software development platform of smartphones; smartphone applications; low power design techniques.

152A. Digital Design Principles

(5) STAFF
Prerequisite: ECE 15A and 2A or ECE 10A & ECE 10AL with a minimum grade of C- in each course; or Computer Science 30 or 64 with a minimum grade of C- in each course; open to electrical engineering, computer engineering, and computer science majors only. Lecture: 3 hours; Laboratory: 6 hours

153A. Hardware/Software Interface

(4) KRIKNTZ
Prerequisite: Upper division standing in Computer Engineering, Computer Science or Electrical Engineering.
- Same course as Computer Science 153A. Issues in interfacing computing systems and soft-
ware to practical I/O interfaces. Rapid response, real-
time events and management of tasks, threads, and scheduling required for efficient design of embed-
ded software and systems is discussed. Techniques for highly constrained systems.

153B. Sensor and Peripheral Interface Design

(4) STAFF
Prerequisite: ECE 152A with a minimum grade of C-. Lecture: 3 hours; Laboratory: 3 hours
- Hardware description languages; field-programm-
able logic and ASIC design techniques. Mixed-
signal techniques: A/D and D/A converter interfaces; video and audio signal acquisition, processing and generation, communication and network interfaces.

154A. Introduction to Computer Architecture

(4) PARNAMI
Prerequisites: ECE 152A with a minimum grade of C-; open to EE and CMPEN majors only. Lecture: 3 hours; Discussion: 1 hour
- Not open for credit to students who have completed Computer Science 154. ECE 154A is the formerly numbered ECE 154. Students who have taken ECE 154 and have received a grade of C- or lower may take ECE 154A for a better grade.
- Instruction-set architecture (ISA) and computer performance; Machine instructions, assembly, ad-
ressing modes; Memory map, arrays, pointers; Procedure calls; Numbers, formats; Simple ALUs; Data path, control, microprogram; Buses, I/O programming, interrupts; Pipelined data paths and control schemes.

154B. Advanced Computer Architecture

(4) STRUKOV
Prerequisite: ECE 154A with a C- grade or better. Open to EE and CMPEN majors only. Lecture: 3 hours; Laboratory: 4 hours
- Not open for credit to those who have taken Com-
puter Science 154.
- ISA variations; Pipeline data and control hazards; Fast ALU design; Instruction-level parallelism, multi-
threading, VLIW; Vector and array processing, multi-/ many-core chips; Caches and memory; Disk; shared- and distributed-memory systems, supercomputers; Reconfigurable and application-specific circuits.
157A. Machine Learning in Design and Test Automation
(4) LI C. WANG
Prerequisite: ECE 152A with a minimum grade of C-
Introduces the various machine learning tech-
niques and how they are utilized to improve hard-
ware design and test automation
processes. The potential benefits and theoretical bar-
riers for implementing a machine learning solution in
practice are explained.

157B. Artificial Intelligence in Design and Test Automation
(4) LI C. WANG
Prerequisite: ECE 157A with a minimum grade of C-
Introduces an artificial intelligence system view to
apply machine learning in design and test automa-
tion processes. The various components for building an Intelligent Engineering
Assistant (IEA) to perform an engineering task in
an industrial setting are explained.

158. Digital Signal Processing
(4) GIBSON
Prerequisites: ECE 130A-B with a minimum grade of C-
in both; open to EE majors only.
Lecture, 3 hours; laboratory, 3 hours.
Recommended Preparation: Mathematics 124A.
Mathematics 124A is recommended but not required
Digital Signal Processing, with Applications: The
Fast Fourier transform, discrete cosine transform, and
multirate digital signal processing techniques, with
applications to digital cellular communications and
wireless access points, and audio, voice, still image,
video, and biological signal analysis, recognition and
compression.

160. Multimedia Systems
(4) MANJUNATH
Prerequisites: Upper-division standing; open to elec-
trical engineering, computer engineering, computer
science, and creative studies majors only.
Lecture: 3 hours; Laboratory: 3 hours.
Not open for credit to students who have com-
pleted CMPSC 182.
Introduction to multimedia and applications,
including WWW, image/video databases and video
streaming. Covers media content analysis, media
data organization and indexing (image/video data-
bases), and media data distribution and interaction
(video-on-demand and interactive TV).

162A. The Quantum Description of Electronic Materials
(4) STAFF
Prerequisites: ECE 130A-B and 134 with a minimum
grade of C- in all; open to EE, seniors in the BS/MS
program and Materials graduate students only.
Same course as Materials 162A. Lecture, 4 hours.
Electrons as particles and waves, Schrodinger's
equation and illustrative solutions. Tunneling. Atomic
structure, the exclusion principle and the periodic
table. Bonds. Free electrons in metals, periodic
potential and energy bands.

162B. Fundamentals of the Solid State
(4) STAFF
Prerequisite: ECE 162A with a minimum grade of C-
open to EE, senior students in the BS/MS programs
and Materials graduate students only.
Same course as Materials 162B. Lecture, 3 hours;
discussion, 1 hour.
Crystal lattices and the structure of solids, with
emphasis on semiconductors. Lattice vibrations,
electronic states and energy bands. Electrical and
thermal conduction. Dielectric and optical properties.
Semiconductor devices: diffusion, p-n junctions and
diode behavior.

162C. Optoelectronic Materials and Devices
(4) STAFF
Prerequisites: ECE 162A-B with a minimum grade of C-
open to electrical engineering and materials
majors only. Lecture, 3 hours; discussion, 1 hour.
Optical transitions in solids. Direct and indirect
gap semiconductors. Luminescence. Excitons and photons. Fundamentals of optoelectronic devices:
semiconductor lasers, Led's, photoconductors, solar
cells, photodiodes, modulators. Photoemission.
Integrated circuits.

178. Introduction to Digital Image and Video Processing
(4) STAFF
Prerequisites: open to EE, computer engineering,
and computer science majors with upper-division
standing. Lecture, 3 hours; discussion, 1 hour.
Basic concepts in image and video processing.
Topics include image formation and sampling, image
transforms, image enhancement, and image and
video compression including JPEG and MPEG cod-
ing standards.

179D. Introduction to Robotics: Dynamics and Control
(4) BYL
Prerequisites: ECE 130A or ME 155A (may be taken concurrently).
Same course as ME 179D.
Dynamic modeling and control methods for ro-
botic systems. LaGrangian method for deriving equa-
tions of motion, introduction to the Jacobian, and
modeling and control of forces and contact dynamics at
a robotic end effector. Laboratories encourage a
problem-solving approach to control.

179P. Introduction to Robotics: Planning and Kinematics
(4) BULLO
Prerequisites: ENGR 3; and either ME 17 or ECE
130C (may be taken concurrently).
Not open for credit to student who have completed Mechanical
Engineering 170A or ECE 181.
Same course as ME 179P.
Motion planning and kinematics topics with an
emphasis on geometric reasoning, programming,
and matrix computations. Motion planning: configu-
ration spaces, sensor-based planning, decomposi-
tion and sampling methods, and advanced planning
algorithms. Kinematics: reference frames, rotations
and displacements, kinematic motion models.

180. Introduction to Deep Learning
(4) MANJUNATH
Prerequisite: Open to EE, Computer Engineering
and Computer Science with upper-division standing.
Introduction to multilayered neural networks, early
models of perceptions and associative memory,
back-propagation learning; convolutional neural
networks; recurrent neural networks; attention mod-
els; applications to natural language processing and
computer vision.

181. Introduction to Computer Vision
(4) MANJUNATH
Prerequisite: Upper-division standing in Electrical
Engineering, Computer Engineering, Computer Sci-
ence, Chemical Engineering or Mechanical Engineer-
ing. Lecture: 3 hours; Discussion: 1 hour.
Same course as Computer Science 181B.
Repeat Comments: Not open for credit to stu-
dents who have completed ECE/CMPSC 181B with
a grade of C or better. ECE/CMPSC 181B is a legal
repeat of ECE/CMPSC 181B.
Overview of computer vision problems and
theories for analyzing the content of images and
video. Topics include image formation, edge
detection, image segmentation, pattern recognition,
texture analysis, optical flow, stereo vision, shape
representation and recovery techniques, issues in
object recognition, and case studies of practical
vision systems.

183. Nonlinear Phenomena
(4) STAFF
Prerequisites: Physics 105A or Physics 103; or ME 163
or upper-division standing in ECE.
Same course as Physics 106 and ME 169. Not
open for credit to students who have completed ECE
163C. Lecture, 3 hours; discussion, 1 hour.
An introduction to nonlinear phenomena. Flows
and bifurcations in one and two dimensions, chaos,
fractals, strange attractors. Applications to physics,
engineering, chemistry, and biology.

188A. Senior Electrical Engineering Project
(3) BEN YAACOV
Prerequisite: ECE 130A and ECE 130B with a C-
grade or better in both; or ECE 137A and ECE 137B
with a C- or better in both.
Student groups design a significant project based
on the knowledge and skills acquired in earlier
coursework and integrate their technical knowledge
through a practical design experience. The project is
evaluated through written reports, oral presentations,
and demonstrations of performance.

188B. Senior Electrical Engineering Project
(3) BEN YAACOV
Prerequisite: ECE 188A with a minimum grade of C-
Lecture: 3 hours; Laboratory: 3 hours.
Student groups design a significant project based
on the knowledge and skills acquired in earlier
coursework and integrate their technical knowledge
through a practical design experience. The project is
evaluated through written reports, oral presentations,
and demonstrations of performance.

189A. Senior Computer Systems Project
(4) ISUKAPALLI
Prerequisite: ECE 153B; senior standing in Computer
Engineering, Computer Science or EE.
Lecture: 3 hours; Laboratory: 3 hours.
Not open for credit to students who have com-
pleted Computer Science 189A-B.
Student groups design a significant computer-
based project. The focus will be on designing a
significant project based on the knowledge and
skills acquired in earlier coursework. Each group works
independently with interaction among groups via
interface specifications and informal meetings. The
project is evaluated through successful completion of
milestones and individual/group project reports and
presentations.

189B. Senior Computer Systems Project
(4) ISUKAPALLI
Prerequisite: ECE 189A; senior standing in Computer
Engineering, Computer Science or EE.
Lecture: 3 hours; Laboratory: 3 hours.
Not open for credit to students who have com-
pleted Computer Science 189A-B.
Student groups design a significant computer-based
project. Focus will be on building and implementing
an embedded hardware system. Each group works
independently. The project is evaluated through
project reports, achieving milestones and through
successful demonstration of hardware functionality.

189C. Senior Computer Systems Project
(4) ISUKAPALLI
Prerequisite: ECE 189B; senior standing in Computer
Engineering, Computer Science or EE.
Lecture: 3 hours; Laboratory: 3 hours.
Not open for credit to students who have com-
pleted Computer Science 189A-B.
Student groups design a significant computer-based
project. The focus in this course will be on
the integration of both hardware and software
components. Students continue to work in groups.
Apart from project reports and presentations, the
evaluation will be based on successful demonstration
of both hardware and software aspects of the project.
192. Projects in Electrical and Computer Engineering
(4) STAFF
Prerequisite: consent of instructor. Discussion, 2 hours; laboratory, 6 hours.
Projects in electrical and computer engineering for advanced undergraduate students.

193. Internship in Industry
(1-8) STAFF
Prerequisite: consent of department. Must have a 3.0 grade-point-average. May not be used as departmental electives. May be repeated to a maximum of 12 units. Field, 1-8 hours.
Special projects for selected students. Offered in conjunction with engineering practice in selected industrial and research firms, under direct faculty supervision.

194AA-ZZ. Special Topics in Electrical and Computer Engineering
(1-5) STAFF

196. Undergraduate Research
(2-4) STAFF
Prerequisites: upper-division standing; consent of instructor. Must have a minimum 3.0 grade-point average for the preceding three quarters. May be repeated for up to 12 units. Not more than 4 units may be applied to departmental electives.
Research opportunities for undergraduate students. Students will be expected to give regular oral presentations, actively participate in a weekly seminar, and prepare at least one written report on their research.

199. Independent Studies in Electrical and Computer Engineering
(1-5) STAFF
Prerequisites: upper division standing; completion of two upper-division courses in electrical and computer engineering; consent of instructor. Must have a minimum 3.0 grade-point average for the preceding three quarters. Students are limited to five units per quarter and 30 units total in all 98/99/198/199/199DC/199RA courses combined.
Directed individual study, normally experimental.

GRADUATE COURSES
Graduate courses for this major can be found in the UCSB General Catalog.
Upper Division

101. Ethics in Engineering
(3) STAFF
Prerequisite: senior standing in engineering.

The nature of moral value, normative judgment, and moral reasoning. Theories of moral value. The engineer’s role in society. Ethics in professional practice. Safety, risk, responsibility. Morality and career choice. Code of ethics. Case studies will facilitate the comprehension of the concepts introduced. (F,W,S,M)

120A. Molecular Bioengineering
(4) STAFF
Prerequisite: Chemistry 1B, Chemistry 1B, Math 68, and Physics 3

Recommended Preparation: One or more undergraduate courses in biochemistry or cell biology similar to MCDB 108ABC or Chem 142ABC or MCDB 103, or consent of instructor.

Enrollment Comments: Quarters usually offered: Winter, Fall.

Introduces students to molecular components of biology with application of engineering principles for analysis. Topics include: molecular components of cells, DNA/RNA structure and function, protein structure/function/folding, gene and protein regulation, DNA replication, and experimental and computational research methods.

120B. Cellular Bioengineering
(4) STAFF
Prerequisite: Engr 120A or consent of Instructor

Enrollment Comments: Quarters usually offered: Winter.

Introduces students to structural components of cells with application of engineering principles for analysis. Topics include: biomembrane structure and function, membrane proteins, membrane transport, intracellular compartments, intracellular trafficking, chemotaxis, cell cycle, apoptosis, and stem cells.

103. Advanced Engineering Writing
(4) STAFF
Prerequisites: Writing 50 or 50E; upper-division standing.

Practice in the forms of communication—contractual reports, proposals, conference papers, oral presentations, business plans—that engineers and entrepreneurial engineers will encounter in professional careers. Focus is on research methods, developing a clear and persuasive writing style, and electronic document preparation.

160. Science for the Public
(1-4) STAFF
Prerequisite: consent of instructor.

Same course as Physics 160K. Open to graduate students in science and engineering disciplines and to undergraduate science and engineering majors.

Provides experience in communicating science and technology to nonspecialists. The major components of the course are field work in mentoring, a biweekly seminar, presentations to precollege students and to adult nonscientists, and end-of-term research papers.

195 A. Multidisciplinary Capstone Design
(1) STAFF
Prerequisite: Engineering 195A.

Enrollment Comments: Quarters usually offered: Winter. Must be enrolled in Capstone project.

This course allows the coordination of senior students in multiple departments while they undertake a multidisciplinary capstone design project. Participating students are required to concurrently enroll in their respective departmental capstone/senior design project courses (ECE 189AB, CMPS 189AB, ECE 188AB, ME 189ABC), and will additionally enroll in 1 unit of this course for the Fall, Winter and Spring quarters. By taking this course, students will understand practical engineering approaches to collaborate on complex multidisciplinary engineering systems.

195 B. Multidisciplinary Capstone Design
(1) STAFF
Prerequisite: Engineering 195B.

Enrollment Comments: Quarters usually offered: Spring. Must be enrolled in Capstone project.

This course allows the coordination of senior students in multiple departments while they undertake a multidisciplinary capstone design project. Participating students are required to concurrently enroll in their respective departmental capstone/senior design project courses (ECE 189AB, CMPS 189AB, ECE 188AB, ME 189ABC), and will additionally enroll in 1 unit of this course for the Fall, Winter and Spring quarters. By taking this course, students will understand practical engineering approaches to collaborate on complex multidisciplinary engineering systems.

195 C. Multidisciplinary Capstone Design
(1) STAFF
Prerequisite: Engineering 195C.

Enrollment Comments: Quarters usually offered: Fall. Must be enrolled in Capstone project.

This course allows the coordination of senior students in multiple departments while they undertake a multidisciplinary capstone design project. Participating students are required to concurrently enroll in their respective departmental capstone/senior design project courses (ECE 189AB, CMPS 189AB, ECE 188AB, ME 189ABC), and will additionally enroll in 1 unit of this course for the Fall, Winter and Spring quarters. By taking this course, students will understand practical engineering approaches to collaborate on complex multidisciplinary engineering systems.

199. Independent Studies in Engineering
(1-5) STAFF
Prerequisite: Upper-division standing; consent of instructor.

Students must have a minimum 3.0 GPA for the preceding three quarters. May be repeated for credit to a maximum of 10 units. Directed individual study.

Graduate Courses

A graduate course listing can be found in the UCSC General Catalog.

Engineering Sciences Courses

Lower Division

3. Introduction to Programming for Engineers
(4) MOEHLIS, PETZOLD
Prerequisites: Open to chemical engineering, electrical engineering, and mechanical engineering majors only.

General philosophy of programming and problem solving. Students will be introduced to the programming language MATLAB. Specific areas of study will include algorithms, basic decision structures, arrays, matrices, and graphing. (F, S, M).

99. Introduction to Research
(1-3) STAFF
Prerequisite: Consent of instructor.

May be repeated for credit to a maximum of 6 units. Students are limited to 5 units per quarter and 30 units total in all 98/99/198/199/199AA-111 courses combined. Directed study to be arranged with individual faculty members. Course offers exceptional students an opportunity to participate in a research group.

177. Art and Science of Aerospace Culture
(4) STAFF
Prerequisites: upper-division standing; consent of instructor.

Same course as Art Studio 177. Interdisciplinary course/seminar/practice for artists, academics, engineers, and designers interested in exploring the technological aesthetic, cultural, and political aspects of the space side of the aerospace complex. Design history, space complex aesthetics, cinema intersections, imaging/telecommunications, human spaceflight history, reduced/alternating gravity experimentation, space systems design/utilization.

Chair & Associate Dean: Glenn E. Beltz

Faculty

Glenn E. Beltz, Ph.D., Harvard, Professor
Jeffrey M. Moehlis, Ph.D., University of California, Berkeley, Professor
Linda R. Petzold, Ph.D., University of Illinois at Urbana-Champaign, Professor
Tyler G. Susko, Lecturer Potential SOE
Robert York, Ph.D., Cornell University, Professor

The Engineering Sciences program at UCSC serves as a focal point for the cross-disciplinary educational environment that prevails in each of our five degree-granting undergraduate programs (chemical engineering, computer engineering, computer science, electrical engineering, and mechanical engineering). The courses offered in this “department” are designed to cultivate well-educated, innovative engineers and scientists with excellent management and entrepreneurial skills and attitudes oriented to new technologies.

One of the missions of the Engineering Sciences program is to provide coursework commonly needed across other educational programs in the College of Engineering. For example, courses in computer programming, computation, ethics, engineering writing, engineering economics, science communication to the public, and even an aeronautics-inspired art course are offered.
Materials

Department of Materials Engineering II, Room 1355; (805) 893-4601
www.materials.ucsb.edu
Chair: Michael L. Chabinyc
Vice Chair: Stephen Wilson

Faculty
Christopher M. Bates, PhD, University of Austin Texas, Assistant Professor (polymer mesostructure and dynamics, energy storage, and crystallization)
Matthew R. Begley, Ph.D., University of California, Santa Barbara, Professor (mechanics of materials with applications to multilayered devices such as microfluidics, MEMS and protective coatings)
Irene J. Beyerlein, Ph.D., Cornell University, Professor (computational materials science, microstructure-property relationships, deformation mechanisms, composites)
John Bowers, Ph.D., Stanford, Distinguished Professor (energy efficiency, optical devices and networks, silicon photonics) *1
Michael Chabinyc, Ph.D., Stanford University, Associate Professor (organic semiconductors, thin film electronics, energy conversion using photovoltaics, characterization of thin films of polymers, x-ray scattering from polymers)
Raphaëlle J. Clément, PhD, University of Cambridge, Assistant Professor (energy storage and conversion using batteries and photoelectrochemical cells, characterization of inorganic (photo) electrochemical materials using magnetic resonance techniques and first principles calculations)
Xi Dai, PhD, Chinese Academy of Sciences, Professor (electronic structure of correlated materials, topological materials, quantum materials, density functional theory)
Steven P. DenBaars, Ph.D., University of Southern California, Distinguished Professor (metalorganic chemical vapor deposition (MOCVD) of semi-conductors, IR to blue lasers and LEDs, high power electronic materials and devices) *1
Daniel S. Gianola, Ph.D., Johns Hopkins University, Associate Professor (nanomechanical behavior of materials, tunable energy conversion, micro- and nanoelectronics, thermal management, and waste heat collection)
John W. Harter, PhD, Cornell University, Assistant Professor (quantum materials, unconventional superconductors, strongly-correlated electrons, nonlinear optical spectroscopy, angle-resolved photoemission spectroscopy)
Craig Hawker, Ph.D., University of Cambridge, Distinguished Professor, Director of Materials Research Laboratory (synthetic polymer chemistry, nanotechnology, materials science)
Sriram Krishnamoorthy, PhD, The Ohio State University, Assistant Professor (ultra-wide band gap semiconductors, epitaxial materials and electronic/photon devices, metalorganic vapor phase epitaxy, Gallium Oxide)
Carlos G. Levi, Ph.D., University of Illinois at Urbana-Champaign, Professor (materials processing, and microstructure evolution, coatings, composites, functional inorganics) *2
Robert M. McMeeking, Ph.D., Brown University, Distinguished Professor (mechanics of materials, fracture mechanics, plasticity, computational mechanics, process modeling) *2
Shuji Nakamura, Ph.D., University of Tokushima, Cree Professor of Solid State Lighting and Displays (gallium nitride, blue lasers, white LEDs, solid state illumination, bulk GaN substrates)
Chris Palmstrøm, Ph.D., University of Leeds, Distinguished Professor (atomic level control of interfacial phenomena, in-situ STM, surface and thin film analysis, metallization of semiconductors, dissimilar materials epitaxial growth, molecular beam and chemical beam epitaxial growth of metallic compounds) *1
Philip A. Pincus, Ph.D., UC Berkeley, Distinguished Professor (theoretical aspects of self-assembled biomolecular structures, membranes, polymers, and colloids) *4
Angela A. Pitenis, Ph.D., University of Florida (interfacial engineering, soft materials, surface physics, biotribology, contact mechanics, adhesion, in situ techniques, imaging)
Tresa M. Pollock, Ph.D., Massachusetts Institute of Technology, Distinguished Professor (mechanical and environmental performance of materials in extreme environments, unique high temperature materials processing paths, ultrafast laser-material interactions, alloy design and 3-D materials characterization)
Cyrus R. Safinya, Ph.D., Massachusetts Institute of Technology, Distinguished Professor (biophysics, supramolecular assemblies of biological molecules, non-viral gene delivery systems)
Omar A. Saleh, Ph.D., Princeton University, Assistant Professor (single-molecule biophysics, motor proteins, DNA-protein interactions)
Rachel A. Segalman, Ph.D., University of California, Santa Barbara, Professor (synthesis of macromolecules, self-assembly, electronic properties of molecular and macromolecular materials, transport processes in polymers)
Ram Seshadri, Ph.D., Indian Institute of Science, Professor (inorganic materials, preparation and magnetism of bulk solids and nanoparticles, patterned materials)
James S. Speck, Sc.D., Massachusetts Institute of Technology, Distinguished Professor (nitride semiconductors, III-V semiconductors, ferroelectric and high-K films, microstructural evolution, extended defects, transmission electron microscopy, x-ray diffraction)
Susanne Stemmer, Ph.D., University of Stuttgart, Professor (functional oxide thin films, structure-property relationships, scanning transmission electron microscopy and spectroscopy)
Galen Stucky, Ph.D., Iowa State University, Distinguished Professor (biomaterials, composites, materials synthesis, electro-optical materials catalysis)*5
Chris Van de Walle, Ph.D., Stanford University, Distinguished Professor (novel electronic materials, wide-band-gap semiconductors, oxides)
Anton Van der Ven, Ph.D., Massachusetts Institute of Technology, Associate Professor (First principles prediction of thermodynamic, kinetic and and mechanical properties of alloys, ceramics and compound semiconductors, statistical mechanical methods development, electrochemical energy storage materials, high temperature structural materials corrosion)
Claude Weisbuch, Ph.D., Université Paris VII, Ecole Polytechnique-Palaiseau,
Distinguished Professor (semiconductor physics: fundamental and applied optical studies of quantized electronic structures and photonic-controlled structures; electron spin resonance in semiconductors, optical semiconductor microcavities, photonic bandgap materials)

Stephen Wilson, Ph.D., University of Tennessee, Assistant Professor (Magnetism in complex oxides, phase behaviors in correlated electron systems and quantum materials, spin-orbit coupled materials, quantum criticality, neutron and x-ray scattering, bulk single crystal growth)

Francis W. Zok, Ph.D., McMaster University, Professor (mechanical and thermal properties of materials and structures)

Emeriti Faculty

Anthony K. Cheetham, Ph.D., Oxford University, Professor Emeritus (catalysis, optical materials, X-ray, neutron diffraction) *5

David R. Clarke, Ph.D., University of Cambridge, Professor Emeritus (electrical ceramics, thermal barrier coatings, piezospectroscopy, mechanics of microelectronics) *2

Larry A. Coldren, Ph.D., Stanford University, Kavli Professor in Optoelectronics and Sensors, Director of Optoelectronics Technology Center (semiconductor integrated optics, optoelectronics, molecular beam epitaxy, microfabrication) *1

Arthur C. Gossard, Ph.D., UC Berkeley, Professor Emeritus (epitaxial growth, artificially synthesized semiconductor microstructures, semiconductor devices) *1

Alan J. Heeger, Ph.D., UC Berkeley, Distinguished Professor, Director of Institute for Polymers and Organic Solids, 2000 Chemistry Nobel Laureate (condensed-matter physics, conducting polymers) *4

Evelyn Hu, Ph.D., Columbia University, Professor Emeritus (high-resolution fabrication techniques for semiconductor device structures, process-related materials damage, contact/interface studies, superconductivity) *1

Jacob N. Israelachvili, Ph.D., University of Cambridge, Distinguished Professor (adhesion, friction surface forces, colloids, biosurface interactions) *3

Herbert Kroemer, Dr. Re. Nat., University of Göttingen, Donald W. Whittier Professor of Electrical Engineering, 2000 Physics Nobel Laureate (device physics, molecular beam epitaxy, heterojunctions, compound semiconductors) *1

Noel C. MacDonald, Ph.D., UC Berkeley, Kavli Professor in MEMS Technology (microelectromechanical systems, applied physics, nano-fabrication, electron optics, materials, mechanics, surface analysis) *2

Frederick F. Milstein, Ph.D., UC Los Angeles, Professor Emeritus (crystal mechanics, bonding, defects, mechanical properties) *2

G. Robert Odette, Ph.D., Massachusetts Institute of Technology, Professor (fundamental deformation and fracture, materials in extreme environments, structural reliability, and high-performance composites) *2

Pierre M. Petroff, Ph.D., UC Berkeley, Professor (semiconductor interfaces, defects physics, epitaxy of self assembled quantum structures, quantum dots and nanomagnets, spectroscopy of semiconductor nanostructures) *1

Fred Wudl, Ph.D., UC Los Angeles, Professor (optical and electro-optical properties of conjugated polymers, organic chemistry of fullerenes, and design and preparation of self-mending polymers)

*1 Joint appointment with Electrical & Computer Engineering
*2 Joint appointment with Mechanical Engineering
*3 Joint appointment with Chemical Engineering
*4 Joint appointment with Physics
*5 Joint appointment with Chemistry & Biochemistry

Affiliated Faculty

David Auston, Ph.D. (Electrical and Computer Engineering)

Glenn H. Fredrickson, Ph.D. (Chemical Engineering)

Mahn Won Kim, Ph.D. (Physics)

Gary Leal, Ph.D. (Chemical Engineering)

Gene Lucas, Ph.D. (Chemical Engineering)

The Department of Materials was conceptualized and built under two basic guidelines: to educate graduate students in advanced materials and to introduce them to novel ways of doing research in a collaborative, multidisciplinary environment. Advancing materials technology today—either by creating new materials or improving the properties of existing ones—requires a synthesis of expertise from the classic materials fields of metallurgy, ceramics, and polymer science, and such fundamental disciplines as applied mechanics, chemistry, biology, and solid-state physics. Since no individual has the necessary breadth and depth of knowledge in all these areas, solving advanced materials problems demands the integrated efforts of scientists and engineers with different backgrounds and skills in a research team. The department has effectively transferred the research team concept, which is the operating mode of the high technology industry, into an academic environment.

The department has major research groups working on a wide range of advanced inorganic and organic materials, including advanced structural alloys, ceramics and polymers; high performance composites; thermal barrier coatings and engineered surfaces; organic, inorganic and hybrid semiconductor and photonic material systems; catalysts and porous materials, magnetic, ferroelectric and multiferroic materials; biomaterials and bio-surfaces, including biomedically relevant systems; colloids, gels and other complex fluids; lasers, LEDs and optoelectronic devices; packaging systems; microscale engineered systems, including MEMS.

The groups are typically multidisciplinary involving faculty, postdoctoral researchers and graduate students working on the synthesis and processing, structural characterization, property evaluation, microstructure-property relationships and mathematical models relating micromechanisms to macroscopic behavior.

Materials Courses

LOWER DIVISION

10. Materials in Society, the Stuff of Dreams (4) STAFF

Prerequisites: Not open to engineering, pre-computer science, or computer science majors.

A survey of new technological substances and materials, the scientific methods used in their development, and their relation to society and the economy. Emphasis on uses of new materials in the human body, electronics, optics, sports, transportation, and infrastructure.

UPPER DIVISION

100A. Structure and Properties I (3) STAFF

Prerequisites: Chemistry 1A-B; Physics 4; and, Mathematics 4B, 6A-B. Lecture, 3 hours.


100B. Structure and Properties II (3) STAFF

Prerequisites: Materials 100A.

Students who take Matrl 101 & 100B will only receive major credit for one of these courses. Lecture, 3 hours.

100C. Fundamentals of Structural Evolution (3) STAFF
Prerequisite: Materials 100A and Materials 100B.

101. Introduction to the Structure and Properties of Materials (3) STAFF
Prerequisite: upper-division standing.
Students who take MATRL 101 & 100B will only receive major credit for one of these courses. Students interested in following the BS Engineering/MS Materials program should not take this course. Introduction to the structure of engineering materials and its relationship with their mechanical properties. Structure of solids and defects. Concepts of microstructure and origins. Elastic, plastic flow and fracture properties. Mechanisms of deformation and failure. Stiffening, strengthening, and toughening mechanisms.

135. Biophysics and Biomolecular Materials (3) SAPINTA
Prerequisites: Physics 5 or 6C or 25.
Same course as Physics 135.
Structure and function of cellular molecules (lipids, nucleic acids, proteins, and carbohydrates). Genetic engineering techniques of molecular biology. Biomolecular materials and biomedical applications (e.g., bio-sensors, drug delivery systems, gene carrier systems).

160. Introduction to Polymer Science (3) STAFF
Prerequisite: Chemistry 109A-B.
Same course as Chemical Engineering 160. Introductory course covering synthesis, characterization, structure, and mechanical properties of polymers. The course is taught from a materials perspective and includes polymer thermodynamics, chain architecture, measurement and control of molecular weight as well as crystallization and glass transitions.

162A. The Quantum Description of Electronic Materials (4) STAFF
Prerequisites: ECE 130A-B and 134 with a minimum grade of C- in all; open to EE and Materials majors only.
Same course as ECE 162A. Electrons as particles and waves, Schrodinger’s equation and illustrative solutions. Tunneling. Atomic structure, the Exclusion Principle and the periodic table. Bonds. Free electrons in metals. Periodic potentials and energy bands. (F)

162B. Fundamentals of the Solid State (4) STAFF
Prerequisites: ECE 162A with a minimum grade of C; open to EE and materials majors only.
Same course as ECE 162B. Crystal lattices and the structure of solids, with emphasis on semiconductors. Lattice vibrations, electronic states and energy bands. Electrical and thermal conduction. Dielectric and optical properties. Semiconductor devices: Diffusion, P-N junctions and diode behavior.

185. Materials in Engineering (3) STAFF
Prerequisite: Materials 100B or 101.
Same course as ME 185. Lecture, 3 hours. Introduces the student to the main families of materials and the principles behind their development, selection, and behavior. Discusses the generic properties of metals, ceramics, polymers, and composites more relevant to structural applications. The relationship of properties to structure and processing is emphasized in every case.

186A. Manufacturing and Materials (3) LEVI
Prerequisites: ME 15 and 151C, and Materials 100B or 101.
Same course as ME 186. Lecture, 3 hours. Introduction to the fundamentals of common manufacturing processes and their interplay with the structure and properties of materials as they are transformed into products. Emphasis on process understanding and the key physical concepts and basic mathematical relationships involved in each of the processes discussed.

186B. Introduction to Additive Manufacturing (3) BEGLEY
Same course as ME 186B. Lecture 3 hours Introduction to additive manufacturing processes: a review of manufacturing methods and process selection consideration, economies of production, common additive manufacturing strategies, and a brief description of the physics of photopolymerization, extrusion, selective laser melting and e-beam melting fabrication.

188. Topics in Materials (2) VANDEWALLE
Topics in Materials for renewable energy-efficient applications: Thermoelectrics, Solid State Lighting, Solar Cells, High Temperature coatings for turbines and engines. (W)

GRADUATE COURSES
Graduate courses for this major can be found in the UCSB General Catalog
Mechanical Engineering

Department of Mechanical Engineering, Engineering II, Room 2355; Telephone (805) 893-2430
Web site: www.me.ucsb.edu
Chair: Jeffrey Moehlis
Vice Chair: Samantha Daly

Faculty

Bassam Bamieh, Ph.D., Rice University, Professor (control systems design with applications to fluid flow problems)
Matthew R. Begley, Ph.D., University of California, Santa Barbara, Professor (mechanics of materials with applications to layered devices such as microfluidics, MEMS and protective coatings)
Glenn E. Beltz, Ph.D., Harvard, Professor (solid mechanics, materials, aeronautics, engineering education)
Ted D. Bennett, Ph.D., UC Berkeley, Associate Professor (thermal science, laser processing)
Irene J. Beyerlein, PhD, Cornell University, Professor (structural mechanics of multi-phase micro- and nanostructured materials, design of metallic alloys) Joint Appointment: MATRL
Francesco Bullo, Ph.D., California Institute of Technology, Professor (motion planning and coordination, control systems, distributed and adaptive algorithms)
Otger Campas, Ph.D., Curie Institute (Paris) and University of Barcelona, Assistant Professor (physical biology, systems biology, quantitative biology, morphogenesis and self-organization of living matter)
Samantha H. Daly, PhD, California Institute of Technology, Associate Professor (mechanics of materials, development of small-scale experimental methods, effects of microstructure on the meso and macroscopic properties of materials, active materials, composites, fatigue, plasticity, fracture)
Emelie Dressiaire, Ph. D., Harvard University, Assistant Professor (learning about and learning from biological and natural processes to control fluid flow and transport)
Frederic Gibou, Ph.D., University of California, Los Angeles, Professor (computational science and engineering) *2
Elliot W. Hawkes, Ph. D., Stanford University, Assistant Professor (Design, mechanics, and non-traditional materials)
to advance the vision of robust, adaptable, human-safe robots that can thrive in the uncertain, unstructured world)
Stephen Laguette, M.S., University of California, Los Angeles, Lecturer (biomedical engineering design)
Carlos Levi, Ph.D., University of Illinois at Urbana-Champaign, Professor (conceptual design, synthesis and evolution in service of structural and inorganic materials, especially for high temperature applications) *3
Bolin Liao, PhD, Massachusetts Institute of Technology, Assistant Professor (nanoscale energy transport and its application to sustainable energy technologies)
Paolo Luzzato-Fegiz, PhD, Cornell University, Assistant Professor (fluid mechanics, wind energy and instrument development)
Eric F. Matthis, Ph.D., California Institute of Technology, Professor (heat transfer, fluid mechanics, rheology)
Robert M. McMeeking, Ph.D., Brown University, Distinguished Professor (mechanics of materials, fracture mechanics, plasticity, computational mechanics) *3
Eckart Meiburg, Ph.D., University of Karlsruhe, Distinguished Professor (computational fluid dynamics, fluid mechanics)
Carl D. Meinhart, Ph.D., University of Illinois at Urbana-Champaign, Professor (wall turbulence, microfluidics, flows in complex geometries)
Igor Mezic, Ph.D., California Institute of Technology, Professor (applied mechanics, non-linear dynamics, fluid mechanics, applied mathematics)
Jeffrey M. Moehlis, Ph.D., University of California, Berkeley, Professor (nonlinear dynamics, fluid mechanics, biological dynamics, applied mathematics)
Sumita Pennathur, Ph.D., Stanford University, Associate Professor (application of microfabrication techniques and micro/nanoscale flow phenomena)
Linda R. Petzold, Ph.D., University of Illinois at Urbana–Champaign, Distinguished Professor, Director of Computational Science and Engineering Graduate Emphasis (computational science and engineering; systems biology) *2
Beth Pruit, Ph. D., Standford University, Professor (mechanobiology, microfabrication, engineering and science, engineering microsystems, and biointerfaces for quantitative mechanobiology.) *4
Alban Sauret, Ph. D., IRPHE, Aix-Marseille University, Assistant Professor (investigating fluid dynamics, interfacial effects and particle transport mechanisms involved in environmental and industrial processes)
Tyler G. Susko, Ph.D., Massachusetts Institute of Technology, Assistant Teaching Professor (mechanical and product design, engineering education, rehabilitation robotics, human-machine interaction)
Geoff Tsai, Ph.D., Massachusetts Institute of Technology, Assistant Teaching Professor (product design, early-stage design process, visual and physical design representation, design education)
Megan Valentine, Ph.D., Harvard University, Assistant Professor (single-molecule biophysics, cell mechanics, motor proteins, biomaterials)
Henry T. Yang, Ph.D., Cornell University, Distinguished Professor (aerospace structures, structural dynamics and stability, transonic flutter and aeroelasticity, intelligent manufacturing systems)

Emeriti Faculty

John C. Bruch, Jr., Ph.D., Stanford University, Professor Emeritus (applied mathematics, numerical solutions and analysis)
David R. Clarke, Ph.D., University of Cambridge, Professor (electrical ceramics, thermal barrier coatings, piezoelectroscopy, mechanics of microelectronics) *3
Roy S. Hickman, Ph.D., UC Berkeley, Professor Emeritus (fluid mechanics, physical gas dynamics, computer-aided design)
George Homsy, Ph.D., University of Illinois, Professor Emeritus (hydrodynamic stability, thermal convection, thin film hydrodynamics, flow in microgeometries and in porous media, polymer fluid mechanics)
Keith T. Kedward, Ph.D., University of Wales, Professor (design of composite systems)
Wilbert J. Lick, Ph.D., Rensselaer Polytechnic Institute, Professor Emeritus (oceanography and limnology, applied mathematics)
Gene Lucas, Ph.D., Massachusetts Institute of Technology, Professor (mechanical properties of structural materials, environmental effects, structural reliability)
Noel C. MacDonald, Ph.D., UC Berkeley, Kavli Professor in MEMS Technology (microelectromechanical systems, applied physics, materials, mechanics, nanofabrication) *3
Ekkehard P. Marschall, Dr. Ing., Technische Hochschule Hannover, Professor Emeritus (thermodynamics, heat and mass transfer, desalination, energy conversion, experimental techniques)
Stephen R. McLean, Ph.D., University of Washington, Professor Emeritus (fluid mechanics, physical oceanography, sediment transport)
Frederick Milstein, Ph.D., UC Los Angeles, Professor Emeritus (mechanical properties of materials) *3
Thomas P. Mitchell, Ph.D., California Institute of Technology, Professor Emeritus (theoretical and applied mechanics)
George R. Odette, PhD, Massachusetts Institute of Technology Joint Appointment: MATRL
Bradley E. Paden, Ph.D., UC Berkley, Professor Emeritus (control theory, kinematics, robotics)
Theofanis G. Theofanous, Ph.D., University of Minnesota, Professor, Director of Center for Risk Studies and Safety (nuclear and chemical plant safety, multiphase flow, thermal hydraulics) *1
Marshall Tulin, M.S., Massachusetts Institute of Technology, Professor Emeritus, Ocean Engineering Laboratory Director (hydrodynamics, aerodynamics, turbulence, cavitation phenomena, drag reduction in turbulent flows)
Walter W. Yuen, Ph.D., UC Berkeley, Professor (thermical science, radiation heat transfer, heat transfer with phase change, combustion)
Enoch H. Yeung, Ph.D., California Institute of Technology, Assistant Professor (control theory, machine learning, synthetic biology, and systems biology)

Affiliated Faculty
Paul J. Atzberger (Mathematics)
Katie A. Byl (Electrical and Computer Engineering)
Hector D. Ceniceros, PhD (Mathematics)
Tommy D. Dickey, PhD (Geography)
Kimberly L. Foster, PhD (Mechanical Engineering)
Joao P. Hespanha, PhD (Electrical and Computer Engineering)
Patricia Holden (Bren School of Environmental Science and Management)
Arturo Keller (Bren School of Environmental Science and Management)
L. Gary Leal (Chemical Engineering)
Kevin W. Plaxco, PhD (Chemistry and Biochemistry, Biomolecular Science and Engineering Program)
Yon Visell, PhD (Electrical and Computer Engineering and Materials)
Libe Washburn, PhD (Geography)

Student Outcomes
Upon graduation, students from the ME program at UCSB are expected to have:
1. An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.
2. An ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors.
3. An ability to communicate effectively with a range of audiences.
4. An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgements, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts.
5. An ability to function effectively on a team whose members together create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives.
6. An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering to draw conclusions.
7. An ability to acquire and apply

Mission Statement
We offer an education that prepares our students to become leaders of the engineering profession and one which empowers them to engage in a lifetime of learning and achievement.

Educational Objectives for the Undergraduate Program
It is the objective of the Mechanical Engineering Program to produce graduates who:
1. Successfully practice in either the traditional or the emerging technologies comprising mechanical engineering;
2. Are successful in a range of engineering graduate programs;
3. Have a solid background in the fundamentals of engineering allowing them to pass the Fundamentals of Engineering examination;
4. Engage in life-long learning opportunities such as professional workshops and activity in professional societies.

In order to achieve these objectives, the Department of Mechanical Engineering is engaged in a very ambitious effort to lead the discipline in new directions that will be critical to the success of 21st century technologies. While maintaining strong ties to STEM areas of the discipline, we are developing completely new cross-cutting fields of science and engineering related to topics such as: microscale engineering and microelectrical-micromechanical systems; dynamics and controls and related areas of sensors, actuators and instrumentation; advanced composite materials and smart structures; computation, simulation and information science; advanced energy and transportation systems; and environmental monitoring, modeling and remediation.
new knowledge as needed, using appropriate learning strategies.

Undergraduate Program

Bachelor of Science—Mechanical Engineering

A minimum of 180 units is required for graduation. A complete list of requirements for the major can be found on page 54. Schedules should be planned to meet both General Education and major requirements.

Students who are not Mechanical Engineering majors may be permitted to take lower division mechanical engineering courses, subject to meeting prerequisites and grade-point average requirements, availability of space, and consent of the instructor.

The mechanical engineering elective course allows students to acquire more in-depth knowledge in one of several areas of specialization, such as those related to: the environment; design and manufacturing; thermal and fluid sciences; structures, mechanics, and materials; and dynamics and controls. A student's specific engineering elective course selection is subject to the approval of the department advisor.

Courses required for the pre-major or major, inside or outside of the Department of Mechanical Engineering, cannot be taken for the passed/not passed grading option. They must be taken for letter grades.

Research Opportunities

Upper-division undergraduates have opportunities to work in a research environment with faculty members who are conducting current research in the various fields of mechanical engineering. Students interested in pursuing undergraduate research projects should contact individual faculty members in the department.

Mechanical Engineering Courses

LOWER DIVISION

6. Basic Electrical and Electronic Circuits
(4) MARKS
Prerequisites: Physics 3-3L; Mathematics 4A; open to ME majors only.

Not open to credit to students who have completed ECE 2A or 2B, or ECE 6A or 6B, or ECE 10A and 10AL, or ECE 10B or 10BL.

Introduction to basic electrical circuits and electronics. Includes Kirchhoff's laws, phasor analysis, circuit elements, operational amplifiers, and transistor circuits.

(4) SUSKO
Prerequisite: ME majors only.

Course materials fee required.

Introduction to engineering graphics, CAD, and freehand sketching. Develop CAD proficiency using advanced 3-D software. Graphical presentation of design: views, sections, dimensioning, and tolerancing.

11. Introductory Concepts in Mechanical Engineering
(1) FIELDS
Prerequisite: lower-division standing.

The theme question of this course is: "What do mechanical engineers do?" Survey of mechanical and environmental engineering applications. Lectures by mechanical engineering faculty and practicing engineers.

12. Manufacturing Processes
(1) FIELDS
Prerequisite: ME majors only.

Processes used to convert raw material into finished objects. Overview of manufacturing processes including: casting, forging, machining, presswork, plastic and composite processing. Videos, demonstrations, and tours illustrate modern industrial practice. Selection of appropriate processes.

12S. Introduction to Machine Shop
(1) LINLEY
Prerequisite: ME majors only.

Course materials fee required.

Basic machine shop skills course. Students learn to work safely in a machine shop. Students are introduced to the use of hand tools, the lathe, the milling machine, drill press, saws, and precision measuring tools. Students apply these skills by completing a project.

14. Statics
(4) DAHL, BREGEL, MCINERNEY
Prerequisite: Math 3B, or AP Calculus AB with a score of 5, or AP Calculus BC with a score of 3 or better; and Physics 1

Introduction to applied mechanics. Forces, moments, couples, and resultants; vector algebra; construction of free body diagrams; equilibrium in 2- and 3-dimensions; analysis of frames, machines, trusses and beams; distributed forces; friction.

15. Strength of Materials
(4) BELTZ
Prerequisites: ME 14 with a minimum grade of C-; open to mechanical engineering majors only.

Properties of structural materials, including Hooke's law and behavior beyond the elastic limit. Concepts of stress, strain, displacement, force, force systems, and multiaxial stress states. Design applications to engineering structures, including problems of bars in tension, compression, and torsion, beams subject to flexure, pressure vessels, and buckling.

(4) CAMPS
Prerequisites: Physics 2; ME 14 with a minimum grade of C-; and Mathematics 6B; (may be taken concurrently); open to ME majors only.


17. Mathematics of Engineering
(3) GIBOU
Prerequisite: Engineering 3; Mathematics 6A (may be taken concurrently); open to ME majors only.

Introduction to basic numerical and analytical methods, with implementation using MATLAB. Topics include root finding, linear algebraic equations, introduction to matrices, determinants, inverses and eigenvalues, curve fitting and interpolation, and numerical differentiation and integration. (S, M)

95. Introduction to Mechanical Engineering
(1-4) STAFF
Prerequisite: consent of instructor.

May be repeated for credit to a maximum of 6 units. Participation in projects in the laboratory or machine shop. Projects may be student- or faculty-originated depending upon student interest and consent of faculty member.

97. Mechanical Engineering Design Projects
(1-4) STAFF
Prerequisite: consent of instructor.

May be repeated for a maximum of 12 units, variable hours.

Course offers students opportunity to work on established departmental design projects. P/NP grading, does not satisfy technical elective requirement.

99. Introduction to Research
(1-3) STAFF
Prerequisite: consent of instructor.

May be repeated for a maximum of 6 units. Students are limited to 5 units per quarter and 30 units total in all 98/99/198/199/199AA-ZZ courses combined.

Directed study to be arranged with individual faculty members. Course offers exceptional students an opportunity to participate in a research group.

UPPER DIVISION

100. Professional Seminar
(1) STAFF
Prerequisite: undergraduate standing.

May be repeated for up to 3 units. May not be used as a departmental elective.

A series of weekly lectures given by university staff and outside experts in all fields of mechanical and environmental engineering.

102. Finite Elements Analysis of Heat Transfer and Fluid Flow with COMSOL
(3) MATTHYS
Prerequisite: ME 151C and ME 152B, or consent by instructor


104. Mechatronics
(4) STAFF
Prerequisites: ME 6; open to ME majors only.

Interfacing of mechanical and electrical systems and mechatronics. Basic introduction to sensors, actuators, and computer interfacing and control. Transducers and measurement devices, actuators, A/D and D/A conversion, signal conditioning and filtering. Practical skills developed in weekly lab exercises.

105. Mechanical Engineering Laboratory
(4) VALENTINE, BENNETT
Prerequisite: ME 151B, 152B, or Materials 101 or 100B.

Introduction to fundamental engineering laboratory measurement techniques and report writing skills. Experiments from thermosciences, fluid mechanics, mechanics, materials science and environmental engineering. Introduction to modern data acquisition and analysis techniques. (S)

110. Aerodynamics and Aeronautical Engineering
(3) BELTZ, MEINHART
Prerequisites: ME 14 and 152A.

Concepts from aerodynamics, including lift and drag analysis for airfoils as well as aircraft sizing/scaling issues. Structural mechanics concepts are applied to practical aircraft design. Intended for students considering a career in aeronautical engineering.
112. Energy
(3) MATTHYS
Prerequisite: Senior Undergraduate or Graduate Student status in the College of Engineering, or consent of Instructor.
Introduction to the field of Energetics. Topics may include energy sources and production, energy usage, renewable technologies, hardware, operating principles, environmental impact, energy reserves, national and global energy budgets, historical perspectives, economics, societal considerations, and others.

124. Advanced Topics in Transport Phenomena/Safety
(3) STAFF
Prerequisites: Chemical Engineering 120A-B-C, or ME 151A-B and ME 152A.
Same course as Chemical Engineering 124.

125AA-2Z. Special Topics in Mechanical Engineering
(3) STAFF
Prerequisite: Consent of instructor.
May be repeated for credit to a maximum of 12 units provided letter designations are different. Students are advised to consult their faculty advisor before making their course selection.

Individual courses each concentrating on one area in the following subjects: applied mechanics, cam, controls, design, environmental engineering, fluid mechanics, materials science, mechanics of solids and structures, ocean and coastal engineering, robotics, theoretical mechanics, thermal sciences, and recent developments in mechanical engineering.

128. Design of Biomedical Devices
(3) LAUGUET
Prerequisite: Mechanical Engineering 10, 14, 15, 16, and 153; open to ME majors only.
Course materials fee may be required.
Introductory course addresses the challenges of biomedical device design, prototyping and testing, material considerations, regulatory requirements, design control, human factors and ethics.

134. Advanced Thermal Science
(3) MATTHYS
Prerequisite: ME 151C.
The class will address advanced topics in fluid mechanics, heat transfer, and thermodynamics. Topics of interest may include combustion, phase change, experimental techniques, materials processing, manufacturing, engines, HVAC, non-Newtonian fluids, etc.

140A. Numerical Analysis in Engineering
(3) MEIBURG
Prerequisites: ME 17 with a minimum grade of C- or Chemical Engineering 132A; open to ME and Chemical Engineering majors only.
Numerical analysis and analytical solutions of problems described by linear and nonlinear differential equations with an emphasis on MATLAB. First and second order differential equations; systems of differential equations; linear algebraic equations, matrices and eigenvalues; boundary value problems; finite differences. (F)

140B. Theoretical Analysis in Mechanical Engineering
(3) MOEHLIS, GIBOU, MEIBURG
Prerequisites: ME 140A.
Analysis of engineering problems formulated in terms of partial differential equations. Solutions of these mathematical models by means of analytical and numerical methods. Physical interpretation of the results.

141A. Introduction to Nanoelectromechanical and Microelectromechanical systems (NEMS/MEMS)
(3) PENNATHUR
Prerequisites: ME 16 & 17; ME 152A & ME 151A (may be concurrent); or ECE 130A & 137A with a minimum grade of C- in both.
Introduction to nano- and microtechnology. Scaling laws and nanoscale physics are stressed. Individual subjects at the nanoscale including materials, mechanics, photonics, electronic fluid, and fluids will be described, with an emphasis on differences of behavior at the nanoscale and real-world examples.

141B. MEMS: Processing and Device Characterization
(4) PENNATHUR
Prerequisites: ME 141A, ME 163 (may be concurrent); or ECE 141A.
Same course as ECE 141B.
Lectures and laboratory on semiconductor-based processing for MEMS. Description of key equipment and characterization tools used for MEMS and design, fabrication, characterization and testing of MEMS. Emphasis on current MEMS devices including accelerometers, comb drives, micro-reactors and capacitor actuators. (W)

146. Molecular and Cellular Biomechanics
(3) VALYUNE
Course introduces fundamental concepts in molecular and cellular biomechanics. Will consider the role of physical, thermal and chemical forces, examine their influence on cell strength and elasticity, and explore the properties of enzymatically-active materials. (F)

147. Mechatronics Using Labview
(3) HARE
Prerequisite: Engineering 3; and ME 6
Not open for additional credit to students who have completed ME 125CH. Course materials fee required.
Introduction to mechatronics, electromechanical systems, data acquisition, software programming and Labview. Students learn programming fundamentals, hardware interfacing and controls with simulated hardware and actual motor controllers. Students compete to control a motor system through a variety of control problems. Final projects automate working hardware in research labs.

151A. Thermosciences
(1) BENNETT, MEINHART
Prerequisite: Physics 2; ME 14 with a minimum grade of C-; and, Mathematics 68.
Basic concepts in thermodynamics, system analysis, energy, thermodynamic laws, and cycles. (F)

151B. Thermosciences
(4) BENNETT, MEINHART
Prerequisites: ME 151A and 152A.
Introduction to heat transfer processes, steady and unsteady state conduction, multidimensional analysis. Introduction to convective heat transfer. (W)

151C. Thermosciences
(3) BENNETT, SAUBERT
Prerequisites: ME 151B and 152B; open to ME majors only.
Convective heat transfer, external and internal flow, forced and free convection, phase change, heat exchangers. Introduction to radiative heat transfer.

152A. Fluid Mechanics
(4) CAMPAS, MEINHART
Prerequisites: Mathematics 6B; and ME 16 with a minimum grade of C-.
Introduction to the fundamental concepts in fluid mechanics and basic fluid properties. Basic equations of fluid flow. Dimensional analysis and similarity. Hydrodynamics. (F)

152B. Fluid Mechanics
(3) LUZZATTO
Prerequisite: ME 152A; open to ME majors only.
Incompressible viscous flow. Boundary-layer theory. Introductory considerations for one-dimensional flow.

153. Introduction to Mechanical Engineering Design
(3) HAWKES
Prerequisites: ME 10 and 16; open to ME majors only.
Systems design using mechanics, stress analysis and finite elements. Statistical problems in manufacturing and reliability. Ethics. One paper design project plus the ASME student design project.

154. Design and Analysis of Structures
(3) MCREEING, BEGLEY
Prerequisites: ME 15 and 16 with minimum grades of C-; open to ME majors only.
Introductory course in structural analysis and design. The theories of matrix structural analysis and finite element analysis for the solution of analytical and design problems in structures are emphasized. Lecture material includes structural theory compatibility method, slope deflection method, displacement method and virtual work. Topics include applications to bars, beams, trusses, frames, and solids.

155A. Control System Design
(3) YEUNG, BAMIEH
Prerequisite: ME 17 with a minimum grade of C- and ME 163.
The discipline of control and its application. Dynamics and feedback. The mathematical models: transfer functions and state space descriptions. Simple control design (PID). Assessment of a control problem, specification, fundamental limitations, codesign of system and control.

155B. Control System Design
(3) BAMIEH
Prerequisite: ME 155A. Not open for additional credit to students who have completed ME 106A. An advanced lab course with experiments in dynamical systems and feedback control design. Students design, troubleshoot, and perform detailed, multi-session experiments.

156A. Mechanical Engineering Design - I
(3) SUSKO
Prerequisite: ME 14, with a minimum grade of C- and ME 15, with a minimum grade of C- and MEATRL 101 (or MATRL 101B); or consent of instructor. Open to ME majors only.
The rational selection of engineering materials, and the utilization of Ashby- charts, stress, strain, strength, and fatigue failure consideration as applied to the design of machine elements. Lectures also support the development of system design concepts using assigned projects and involves the preparation of engineering reports and drawings.

156B. Mechanical Engineering Design II
(3) SUSKO
Prerequisites: ME 156A; open to ME majors only.

157. Introduction to Multiphysics Simulation
(3) MEINHART
Prerequisite: Mechanical Engineering 151A-B; and Mechanical Engineering 152A-B; and Mechanical Engineering 140A.
May not be taken for additional credit by students who have completed ME 125CM. May not be taken by students who have completed ME 225CM or ME 257. Course materials fee required.
Introduces students to the concepts of multiphysics simulation. Students are introduced to PDE’s, associated analytical solutions, and the finite elements method. Multiphysics problems are solved in multiple domains, and with fluid/structure interactions. Each student conducts a project where multiphysics tools are used to explore details of multiphysical processes.
158. Computer Aided Design and Manufacturing (3) STAFF
Prerequisites: ME 10 and 156A; open to ME majors only.
Course materials fee required.

162. Introduction to Elasticity (3) MCMEEKING, BELTZ
Prerequisites: ME 15 and 140A.

166. Advanced Strength of Materials (3) DAILY
Prerequisite: ME 15.

167. Structural Analysis (3) YANG
Prerequisites: ME 15. May not be taken for additional credit by students who have completed ME W 167.

169. Nonlinear Phenomena (4) MOHURD
Prerequisites: Physics 105A or ME 163; or upper-division standing in ECE.

179D. Introduction to Robotics: Dynamics and Control (4) BYL
Prerequisites: ECE 130A or ME 155A (may be taken concurrently).

179L. Introduction to Robotics: Design Laboratory (4) STAFF
Prerequisites: ENGR 3; and ME 6 or ECE 2A. Not open for credit to students who have completed Mechanical Engineering 170C or ECE 181C.
Course materials fee required.

179P. Introduction to Robotics: Planning and Kinematics (4) BULLO
Prerequisites: Engr 3; and either ME 17 or ECE 130C (may be taken concurrently). Not open for credit to students who have completed ME 170A or ECE 181A.

185. Materials in Engineering (3) LEVI
Prerequisite: Materials 100B or 101.

186A. Manufacturing and Materials (3) LEVI
Prerequisites: ME 15 and 151C; and, Materials 100B or 101.

186B. Introduction to Additive Manufacturing (3) BEGLEY

189A. Capstone Mechanical Engineering Design Project (3) SUSKO
Prerequisite: ME 189A.
Course materials fee required.

189B. Capstone Mechanical Engineering Design Project (3) SUSKO
Prerequisite: ME 189A
Course materials fee required.

193. Internship in Industry (1-24) STAFF
Prerequisite: consent of instructor and prior departmental approval needed.

197. Independent Projects in Mechanical Engineering Design (1-4) STAFF
Prerequisites: ME 16; consent of instructor.
May be repeated for a maximum of 12 units, variable hours. No more than 4 units may be used as departmental electives.

199. Independent Studies in Mechanical Engineering (1-5) STAFF
Prerequisites: consent of instructor; upper-division standing; completion of two upper-division courses in Mechanical Engineering.

Students must have a minimum of 3.0 grade-point average for the preceding three quarters and are limited to 5 units per quarter and 30 units total in all 98/99/198/199/199DC/199RA courses combined. No more than 4 units may be used as departmental electives. May be repeated to 12 units.
Directed individual study.

GRADUATE COURSES
Graduate courses for this major can be found in the UCSB General Catalog.
Technology Management

Technology Management Program
Phelps Hall, Room 2219
(805) 893-2729
www.tmp.ucsb.edu
Chair: Kyle Lewis

Faculty
Matthew Beane, Ph.D., Massachusetts Institute of Technology, Assistant Professor
John E. Bowers, Ph.D., Stanford University, Distinguished Professor
Gary S. Hansen, Ph.D., University of Michigan, Associate Professor
Paul Leonardi, Ph.D., Stanford University, Professor
Kyle Lewis, Ph.D., Stanford University, Professor
Nelson Phillips, Ph.D., University of Alberta, Professor
Renee Rottner, Ph.D., UC Irvine, Assistant Professor
Jessica Santana, Ph.D., Stanford University, Assistant Professor
Mary Tripas, Ph.D., Massachusetts Institute of Technology, Professor
Robert A. York, Ph.D., Cornell University, Professor

Transitioning new technical advances and discoveries into products or services that benefit society requires business and interpersonal skills as well as technical expertise. These include an ability to work effectively in teams, build sound business models that account for the competitive environment, lead and manage other and diverse groups and apply basic marketing principals.

The Technology Management Program (TMP) provides students a solid foundation in business fundamentals and entrepreneurship as it applies to new technologies and technology-oriented companies. This certificate serves as an official recognition that the student has a solid grounding in fundamental business strategies and models, opportunity recognition and new-venture creation and marketing.

Technology Management Program Courses

21. Past, Present and Future of Entrepreneurship (3) GREATHOUSE
Quarters usually offered: Spring.
The historical and present state of entrepreneurship will be explored, along with the potential future direction of startups. Students will be encouraged to start small ventures as a means of determining their proclivity for an entrepreneurial lifestyle.

34. Selling High Tech Products (4) STAFF
Prerequisite: upper division standing.
Learn the art of persuasion and selling. Theory and applications of the basic tenets of persuasion and how such scientifically supported techniques can be deployed to positively impact the sales process.

111. Issues in Technology, Business, and Society (1) STAFF
Prerequisite: upper division standing.
Enrollment Comments: Quarters usually offered: Fall, Winter, Spring.
Lecture series where entrepreneurial, technological, business, and governmental leaders share their lessons of experience and discuss current business issues. For anyone interested in entrepreneurship, management, technology development, and commercialization and the impact that innovation has on society.

120. Fundamentals of Business Strategy (4) HANSEN
Prerequisite: upper division standing.
Introduction to critical business principles and practices required by leaders for business success and societal benefit. Students will be exposed to key management theories, models and tools in strategy, finance, accounting, commercialization, marketing, and sales.

122. Entrepreneurship (4) STAFF
Prerequisite: TMP 120 with grade of B- or better and upper division standing.
Learn how to start any kind of venture; for profit, non-profit, service, sole proprietorship, with a focus on high-tech ventures. Analysis of new business opportunities, development of customer-centric value propositions, financing, marketing, selling and protection of intellectual property.

124. Principles of Marketing (4) STAFF
Prerequisite: TMP 120 with a grade of B- or better and upper division standing.
Introduces fundamental principles, processes, and tools of marketing which are used to create, communicate and deliver the value of products and services to customers, clients, partners, and society. This is done with an array of essential topics, such as the identification of customer needs and wants, the assessment of the competitive environment, selection of the most appropriate target opportunities, development of an integrated marketing strategy, and disciplined execution.

127. Understanding and Managing Technology Organizations (4) STAFF
Prerequisite: TMP 120 with a grade of B- or better and upper division standing.
Participating in, managing, and leading successful teams, careers, and organizations. Current theories and practices concerning motivation, organizational culture, communications, effective decision making, team effectiveness and others presented and discussed.

131. Introductions to Patents and Intellectual Property (3) STAFF
Provides emerging inventors, entrepreneurs, and scientists with a working knowledge of intellectual property (patents, copyrights, trademarks, and trade secrets), with the main focus being on patents. Will cover the basic functions of patents, structure of patents, and patent prosecution.

148A. New Venture Seminar (3) STAFF
Recommended Preparation: TMP 122, TMP 149, or equivalent.
Quarters usually offered: Winter.
A twice-weekly series of seminars about the creation of sustainable new business ventures from inception to launch. Intended for students participating in the TMP New Venture Competition. (W)

149. Creating a Market-Tested Business Model (4) STAFF
Recommended Preparation: TMP 122.
Quarters usually offered: Winter.
Course provides an experiential learning opportunity, showing how a successful business model can be created through the use of customer and market validation process. (W)

191AA-ZZ. Special Topics in Business and Management (2-4) STAFF
Prerequisite: Upper-division standing.
Enrollment Comments: Students must have a cumulative 3.0 for the preceding 3 quarters. May be repeated for credit provided there is no duplication of course content.
Courses provide for the study of topics of current interest in the areas of business, technology, management, entrepreneurship, and other issues related to management and creation of sustainable businesses.

GRADUATE COURSES
Graduate courses for this program can be found in the UCSB General Catalog.
### CHEMICAL ENGINEERING 2021-22

#### PREPARATION FOR THE MAJOR

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<th>Course</th>
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**Units:** 74

#### UNIVERSITY REQUIREMENTS

**UC Entry Level Writing Requirement:** English Composition

Must be fulfilled within three quarters of matriculation

American History and Institutions – (one 4-unit course, may be counted as G.E. if selected from approved list)

#### GENERAL EDUCATION

**General Subject Areas**

**Area A: English Reading & Comprehension** – (2 courses required)

A-1:  
A-2:  

**Area D: Social Science**

(2 courses minimum)

**Area E: Culture and Thought**

(2 courses minimum)

**Area F: The Arts**

(1 course minimum)

**Area G: Literature**

(1 course minimum)

**Special Subject Areas**

Ethnicity (1 course):

European Traditions  

or World Cultures (1 course):

Writing (4 courses required):

To satisfy major requirements, courses taken inside or outside the Department of Electrical and Computer Engineering, must be taken for a letter grade.

**Total Units Required for Graduation:** 187
## CHEMICAL ENGINEERING 2021-22

This grid is intended to serve as a guide and should be adjusted for individual circumstances in consultation with academic advisors. Course availability subject to change. Changes will be announced by the department.

### FRESHMAN YEAR

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### SOPHOMORE YEAR

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<td>CH E 132A</td>
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<tr>
<td>MATH 4B or 4BI</td>
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<td>CHEM 6AL</td>
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<td>PHYS 3</td>
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<td>CHEM 109B or 109BH</td>
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### JUNIOR YEAR

<table>
<thead>
<tr>
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<td>CH E 118</td>
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<td>CH E 128</td>
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<td>CH E 132C</td>
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<td>CH E 120C</td>
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<tr>
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<td>CHEM 113B</td>
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<td>CH E 140A</td>
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<td>CH E 180A</td>
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<td>CHEM 113C</td>
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### SENIOR YEAR

<table>
<thead>
<tr>
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<th>SPRING</th>
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<td>CH E 140B</td>
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<td>CH E 180B</td>
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<td>CH E 184B</td>
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<td>CH E 152A</td>
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<td>CH E 184A</td>
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<td>G.E.</td>
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<td>TOTAL</td>
<td>14</td>
<td>13</td>
<td>14</td>
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</table>

* If applying to the BS/MS Materials program, student must take:
  * Sophomore year- Phys 4 in Winter or Spring
  * Junior year- MATRL 100A in Fall, MATRL 100B in winter, MATRL 100C in Spring
  * Students may only count one course toward the major. (MATRL 101 OR MATRL 100C)
## COMPUTER ENGINEERING 2021-22

### PREPARATION FOR THE MAJOR

<table>
<thead>
<tr>
<th>Course</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHEM 1A, 1AL or 2A, 2AC</td>
<td>5</td>
</tr>
<tr>
<td>CMPSC 16</td>
<td>4</td>
</tr>
<tr>
<td>CMPSC 24</td>
<td>4</td>
</tr>
<tr>
<td>CMPSC 32</td>
<td>4</td>
</tr>
<tr>
<td>CMPSC 40</td>
<td>5</td>
</tr>
<tr>
<td>ECE 1A-1B</td>
<td>2</td>
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<tr>
<td>ECE 10A, 10AL, 10B, 10BL, 10C, 10CL</td>
<td>15</td>
</tr>
<tr>
<td>ECE 15A</td>
<td>4</td>
</tr>
<tr>
<td>MATH 3A-B, 4A-B</td>
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<td>PHYS 1, 2, 3, 3L, 4, 4L</td>
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### UPPER DIVISION MAJOR

<table>
<thead>
<tr>
<th>Course</th>
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<tbody>
<tr>
<td>CMPSC 130A</td>
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</tr>
<tr>
<td>ECE 139 or PSTAT 120A</td>
<td>4</td>
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<tr>
<td>ECE 152A</td>
<td>5</td>
</tr>
<tr>
<td>ECE 154A</td>
<td>4</td>
</tr>
<tr>
<td>ENGR 101</td>
<td>3</td>
</tr>
<tr>
<td>CMPSC 189 A-B’ / ECE 189” A-B-C</td>
<td>8-12</td>
</tr>
<tr>
<td>* Prerequisite to CMPSC 189A is CMPSC 156</td>
<td></td>
</tr>
<tr>
<td>* Prerequisite to ECE 189A is ECE 153B</td>
<td></td>
</tr>
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</table>

Computer Engineering electives selected from the following list: 36-40

Prior approval of the student’s departmental electives must be obtained from the student’s faculty adviser.

Must include at least 2 sequences. See ECE Department student office for list of approved sequences.

### UNIVERSITY REQUIREMENTS

**UC Entry Level Writing Requirement:** English Composition
Must be fulfilled within three quarters of matriculation

American History and Institutions – (one 4-unit course, may be counted as G.E. if selected from approved list)

### GENERAL EDUCATION

**General Subject Areas**

<table>
<thead>
<tr>
<th>Area</th>
<th>Courses Required</th>
</tr>
</thead>
<tbody>
<tr>
<td>A-1</td>
<td></td>
</tr>
<tr>
<td>A-2</td>
<td></td>
</tr>
</tbody>
</table>

Area D: Social Science
(2 courses minimum)

Area E: Culture and Thought
(2 courses minimum)

Area F: The Arts
(1 course minimum)

Area G: Literature
(1 course minimum)

### Special Subject Areas

Ethnicity (1 course):

European Traditions or World Cultures (1 course):

Writing (4 courses required):

### NON-MAJOR ELECTIVES

Free Electives taken:

<table>
<thead>
<tr>
<th>Course</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td></td>
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</tbody>
</table>

**TOTAL UNITS REQUIRED FOR GRADUATION**: 191

To satisfy major requirements, courses taken inside or outside the Department of Electrical and Computer Engineering, must be taken for a letter grade.
COMPUTER ENGINEERING 2021-22
This grid is intended to serve as a guide and should be adjusted for individual circumstances in consultation with academic advisors.
Course availability subject to change. Changes will be announced by the department.

FRESHMAN YEAR

<table>
<thead>
<tr>
<th>Course</th>
<th>FALL units</th>
<th>WINTER</th>
<th>SPRING units</th>
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</thead>
<tbody>
<tr>
<td>CHEM 1A or 2A</td>
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<td>ECE 1A</td>
<td>1</td>
</tr>
<tr>
<td>CHEM 1AL or 2AC</td>
<td>2</td>
<td>CMPSC 16</td>
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<tr>
<td>MATH 3A</td>
<td>4</td>
<td>MATH 3B</td>
<td>4</td>
</tr>
<tr>
<td>G.E. Elective or CMPSC 8(^1)</td>
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<td>PHYS 1</td>
<td>4</td>
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<tr>
<td>WRIT 1E or 2E</td>
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<td>WRIT 2E or 50E</td>
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SOPHOMORE YEAR

<table>
<thead>
<tr>
<th>Course</th>
<th>FALL units</th>
<th>WINTER</th>
<th>SPRING units</th>
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</thead>
<tbody>
<tr>
<td>CMPSC 24</td>
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<td>ECE 10A</td>
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<td>ECE 10AL</td>
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<td>MATH 4B</td>
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<td>PHYS 3</td>
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<tr>
<td>PHYS 3L</td>
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<td>PHYS 4L</td>
<td>1</td>
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JUNIOR YEAR

<table>
<thead>
<tr>
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<th>WINTER</th>
<th>SPRING units</th>
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<tbody>
<tr>
<td>ECE 154A</td>
<td>4</td>
<td>CMPSC 130A</td>
<td>4</td>
</tr>
<tr>
<td>CMPEN Electives</td>
<td>8</td>
<td>CMPEN Elective(^*)</td>
<td>4</td>
</tr>
<tr>
<td>G.E.</td>
<td>4</td>
<td>G.E.</td>
<td>4</td>
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<tr>
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<td></td>
<td></td>
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<tr>
<td><strong>TOTAL</strong></td>
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<td><strong>16</strong></td>
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SENIOR YEAR

<table>
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<th>WINTER</th>
<th>SPRING units</th>
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</thead>
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<tr>
<td>ECE 189A*/ CMPSC(^+) 189A</td>
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<td>ECE 189B/ CMPSC 189B</td>
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<tr>
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<tr>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>16</strong></td>
<td><strong>15</strong></td>
<td><strong>12</strong></td>
</tr>
</tbody>
</table>

1CMPSC 8 may be used to satisfy the Math, Science, Engineering Elective requirement.
2PSTAT 120A is offered each quarter. ECE 139 is offered only in spring quarter, and is better suited for future upper division electives for the Computer Engineering major.
3 ENGR 101 may be taken any quarter of senior year.
*ECE 189A-B-C is taken fall, winter, and spring quarters. Prerequisite to ECE 189A is ECE 153B, taken winter of junior year.
+CMPSC 189A-B is taken fall and winter quarters. Prerequisite to CMPSC 189A is CMPSC 156.
# COMPUTER SCIENCE 2021-22

**Units**

<table>
<thead>
<tr>
<th>Preparation for the Major</th>
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<td>CMPSC 16</td>
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<td>CMPSC 24</td>
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<td>CMPSC 32</td>
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</tr>
<tr>
<td>CMPSC 40</td>
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<tr>
<td>CMPSC 64</td>
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<td>MATH 3A-B, 4A-B, 6A</td>
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<td>PSTAT 120A</td>
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<thead>
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<th>Upper Division Major</th>
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<td>CMPSC 111 or 140</td>
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<tr>
<td>CMPSC 130A-B</td>
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<tr>
<td>CMPSC 138</td>
<td>4</td>
</tr>
<tr>
<td>CMPSC 148 or 156 or 172</td>
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<td>CMPSC 154</td>
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<tr>
<td>CMPSC 160 or 162</td>
<td>4</td>
</tr>
<tr>
<td>CMPSC 170</td>
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<tr>
<td>ENGR 101</td>
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<tr>
<td>PSTAT 120B</td>
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<tr>
<td>Major Field Electives</td>
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</table>

Eight courses selected from the following list (at least 8 units must be CMPSC courses). Prior approval of the student’s major field electives must be obtained from the faculty advisor.

<table>
<thead>
<tr>
<th>Major Field Electives taken:</th>
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<tbody>
<tr>
<td>CMPSC 111&lt;sup&gt;1&lt;/sup&gt;</td>
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<tr>
<td>CMPSC 140&lt;sup&gt;1&lt;/sup&gt;</td>
</tr>
<tr>
<td>CMPSC 148&lt;sup&gt;2&lt;/sup&gt;</td>
</tr>
<tr>
<td>CMPSC/ECE 153A</td>
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<tr>
<td>CMPSC 156&lt;sup&gt;2&lt;/sup&gt;</td>
</tr>
<tr>
<td>CMPSC 160&lt;sup&gt;3&lt;/sup&gt;</td>
</tr>
<tr>
<td>CMPSC 162&lt;sup&gt;3&lt;/sup&gt;</td>
</tr>
<tr>
<td>CMPSC 165A-B</td>
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<tr>
<td>CMPSC 171/ECE 151</td>
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<tr>
<td>CMPSC 172&lt;sup&gt;2&lt;/sup&gt;</td>
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<tr>
<td>CMPSC 174A-B</td>
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<td>CMPSC 176A-B-C</td>
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<td>CMPSC 177</td>
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<td>CMPSC 178</td>
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<tr>
<td>CMPSC 180</td>
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<tr>
<td>CMPSC 185</td>
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<tr>
<td>CMPSC 189 A-B</td>
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<td>CMPSC 190 AA-ZZ</td>
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<td>CMPSC 192&lt;sup&gt;4&lt;/sup&gt;</td>
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<td>CMPSC 196&lt;sup&gt;5&lt;/sup&gt;</td>
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<td>CMPSC 196B</td>
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<td>ECE 178</td>
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<td>MATH 108A-B</td>
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<td>MATH 119A-B</td>
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<td>MATH 124A-B</td>
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<td>PSTAT 122</td>
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<td>PSTAT 130</td>
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<tr>
<td>PSTAT 160A-B</td>
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<tr>
<td>ECE 130A-B-C</td>
</tr>
</tbody>
</table>

<sup>1</sup> CMPSC 111 or 140 can be used as an elective if not taken as a major course.
<sup>2</sup> CMPSC 148 or 156 or 172 can be used as an elective if not taken as a major course.
<sup>3</sup> CMPSC 160 or 162 can be used as an elective if not taken as a major course.
<sup>4</sup> Four units maximum from CMPSC 192 and 196 combined; only for students with GPA of 3.0 or higher.
<sup>5</sup> Only for students who have met the requirements. Please see department advisor for more information.

## Science Courses

Science Electives (see Dept. for list) . . . . . . . . . . . . . . . . . . 8
Science Electives taken:

<table>
<thead>
<tr>
<th>Science Courses</th>
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<tbody>
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</table>

To satisfy major requirements, courses taken inside or outside the Department of Computer Science, must be taken for a letter grade.

## University Requirements

**UC Entry Level Writing Requirement:** English Composition Must be fulfilled within three quarters of matriculation

<table>
<thead>
<tr>
<th>University Requirements</th>
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</table>

American History and Institutions – (one 4-unit course, may be counted as G.E. if selected from approved list)

<table>
<thead>
<tr>
<th>General Education</th>
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</tbody>
</table>

## General Subject Areas

### Area A: English Reading & Comprehension – (2 courses required)

<table>
<thead>
<tr>
<th>General Subject Areas</th>
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<tbody>
<tr>
<td>A-1:</td>
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<tr>
<td>A-2:</td>
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</tbody>
</table>

### Area D: Social Science

(2 courses minimum)

<table>
<thead>
<tr>
<th>General Subject Areas</th>
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</thead>
<tbody>
<tr>
<td>Area D: Social Science</td>
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</tbody>
</table>

### Area E: Culture and Thought

(2 courses minimum)

<table>
<thead>
<tr>
<th>General Subject Areas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area E: Culture and Thought</td>
</tr>
</tbody>
</table>

### Area F: The Arts

Area G: Literature

(1 course minimum)

<table>
<thead>
<tr>
<th>General Subject Areas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area F: The Arts</td>
</tr>
<tr>
<td>Area G: Literature</td>
</tr>
</tbody>
</table>

## Special Subject Areas

<table>
<thead>
<tr>
<th>Special Subject Areas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ethnicity (1 course):</td>
</tr>
<tr>
<td>European Traditions</td>
</tr>
</tbody>
</table>
or World Cultures (1 course):

<table>
<thead>
<tr>
<th>Special Subject Areas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Writing (4 courses required):</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Special Subject Areas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Writing</td>
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</table>

## Non-Major Electives

Free Electives taken:

<table>
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<th>Non-Major Electives</th>
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<tr>
<td></td>
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<table>
<thead>
<tr>
<th>Non-Major Electives</th>
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</thead>
<tbody>
<tr>
<td>Free Electives taken</td>
</tr>
</tbody>
</table>

## Total Units Required for Graduation

...184
**COMPUTER SCIENCE 2021-22**

This grid is intended to serve as a guide and should be adjusted for individual circumstances in consultation with academic advisors.
Course availability subject to change. Changes will be announced by the department.

**FRESHMAN YEAR**

<table>
<thead>
<tr>
<th>FALL</th>
<th>units</th>
<th>WINTER</th>
<th>units</th>
<th>SPRING</th>
<th>units</th>
</tr>
</thead>
<tbody>
<tr>
<td>G.E. Elective or CMPSC 8(^1)</td>
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<td>CMPSC 16(^1)</td>
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<td>CMPSC 24</td>
<td>4</td>
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<td>MATH 3A</td>
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<td>MATH 3B</td>
<td>4</td>
<td>MATH 4A</td>
<td>4</td>
</tr>
<tr>
<td>WRIT 1, 2, or G.E. Elective</td>
<td>4/5</td>
<td>PHYS 1</td>
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<td>PHYS 2</td>
<td>4</td>
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<tr>
<td>G.E. Elective</td>
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<td>WRIT 1, 2, or G.E. Elective</td>
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<td>Science or Free Elective</td>
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<td><strong>TOTAL</strong></td>
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**SOPHOMORE YEAR**

<table>
<thead>
<tr>
<th>FALL</th>
<th>units</th>
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**JUNIOR YEAR**

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**SENIOR YEAR**

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---

1. Consult Computer Science academic advisor for placement information.
2. Or you may take CMPSC 162 to satisfy this requirement.
3. Or you may take CMPSC 140 in Winter Quarter to satisfy this requirement.
4. ENGR 101 may be taken any quarter of senior year.
**ELECTRICAL ENGINEERING 2021-22**

### PREPARATION FOR THE MAJOR  

<table>
<thead>
<tr>
<th>Course</th>
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<tbody>
<tr>
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<tr>
<td>CMPSC 16</td>
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</tr>
<tr>
<td>ECE 5</td>
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<tr>
<td>ECE 10A, 10AL, 10B, 10BL, 10C, 10CL</td>
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</tr>
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<td>ECE 15A</td>
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### UPPER DIVISION MAJOR  

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<td>ECE 139</td>
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<td>ECE 152A</td>
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Departmental electives selected from the following list:  

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<td>ECE 123</td>
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</tr>
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<td>ECE 142</td>
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</tr>
<tr>
<td>ECE 144</td>
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</tr>
<tr>
<td>ECE 145A-B-C</td>
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<td>ECE 146A-B</td>
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</tr>
<tr>
<td>ECE 147A-B-C</td>
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</tr>
</tbody>
</table>

Departmental electives must be obtained from the student's faculty adviser.  

Must include at least 1 sequence, see ECE Department student office for list of approved sequences. Minimum six courses.

**Approved Departmental Electives:**

- ECE 120A-B
- ECE 122A-B
- ECE 123
- ECE 125
- ECE 130C
- ECE 135
- ECE 141A-B
- ECE 142
- ECE 144
- ECE 145A-B-C
- ECE 146A-B
- ECE 147A-B-C

**TOTAL UNITS REQUIRED FOR GRADUATION**  

**UNIVERSITY REQUIREMENTS**

- UC Entry Level Writing Requirement: English Composition  
  Must be fulfilled within three quarters of matriculation

- American History and Institutions – (one 4-unit course, may be counted as G.E. if selected from approved list)

**GENERAL EDUCATION**

**General Subject Areas**

- Area A: English Reading & Comprehension – (2 courses required)
  - A-1: _________________________  
  - A-2: _________________________

- Area D: Social Science  
  (2 courses minimum)

- Area E: Culture and Thought  
  (2 courses minimum)

- Area F: The Arts  
  (1 course minimum)

- Area G: Literature  
  (1 course minimum)

**Special Subject Areas**

- Ethnicity (1 course): __________   
- European Traditions  
  or World Cultures (1 course): ________

- Writing (4 courses required):
  - __________
  - __________
  - __________
  - __________

**NON-MAJOR ELECTIVES**

Free Electives taken:

- __________
- __________
- __________
- __________

To satisfy major requirements, courses taken inside or outside the Department of Electrical and Computer Engineering, must be taken for a letter grade.
# MAJOR REQUIREMENTS • 59

## FRESHMAN YEAR

<table>
<thead>
<tr>
<th>FALL</th>
<th>units</th>
<th>WINTER</th>
<th>units</th>
<th>SPRING</th>
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<tbody>
<tr>
<td>CHEM 1A or 2A</td>
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<td>MATH 3B</td>
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<td>MATH 4A</td>
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## SOPHOMORE YEAR

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<td>ECE 15A</td>
<td>4</td>
<td>MATH 6B</td>
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## JUNIOR YEAR

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<th>SPRING</th>
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<td>ECE 137A</td>
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## SENIOR YEAR

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<td>G.E.</td>
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1. ECE 139 may also be taken in the spring quarter of the sophomore year.
2. ECE 152A may also be taken in the spring quarter of the sophomore year.
3. ENGR 101 may be taken any quarter of senior year.
4. This course may not be required. Students must complete at least 189 units to graduate.
MECHANICAL ENGINEERING 2021-22

PREPARATION FOR THE MAJOR

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<td>ME 10</td>
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<td>ME 12S</td>
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<td>ME 14</td>
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<td>ME 15</td>
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UPPER DIVISION MAJOR

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1 Specialization Group*

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<td>ME 166</td>
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<td>ME 129</td>
<td>ME 141B</td>
<td>ME 154</td>
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*Two courses required: Either a group, or 1 course from L1 and 1 course from L2

Fourth Year

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<td>ME 156A-B</td>
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Approved Engineering Electives:

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<td>ME 147</td>
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<td>MATRL 188</td>
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<td>ME 102</td>
<td>ME 157</td>
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1ME W167 online version of ME 167.
2Four units maximum from ME 197 and ME 199 combined

To satisfy major requirements, courses taken inside or outside the Department of Mechanical Engineering, must be taken for a letter grade.

UNIVERSITY REQUIREMENTS

UC Entry Level Writing Requirement: English Composition
Must be fulfilled within three quarters of matriculation

Satisfied by:

American History and Institutions – (one 4-unit course, may be counted as G.E. if selected from approved list)

GENERAL EDUCATION

General Subject Areas

Area A: English Reading & Comprehension – (2 courses required)

A-1: __________________________ A-2: __________________________

Area D: Social Science
(2 courses minimum)

Area E: Culture and Thought
(2 courses minimum)

Area F: The Arts
(1 course minimum)

Area G: Literature
(1 course minimum)

Special Subject Areas

Ethnicity (1 course):

European Traditions or World Cultures (1 course):

Writing (4 courses required):

NON-MAJOR ELECTIVES

Free Electives taken:

TOTAL UNITS REQUIRED FOR GRADUATION.....180
## FRESHMAN YEAR

<table>
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<tr>
<th>FALL</th>
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<th>WINTER</th>
<th>units</th>
<th>SPRING</th>
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<td>CHEM 1B or 2B</td>
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<td>MATH 4A</td>
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</tr>
<tr>
<td>CHEM 1AL or 2AC</td>
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<td>CHEM 1BL or 2BC</td>
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<td>ME 10</td>
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<td>MATH 3A</td>
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<td>ENGR 3</td>
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<td>ME 12S(^1)</td>
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<td>WRIT 1E or 2E</td>
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## SOPHOMORE YEAR

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<tr>
<td>MATH 4B</td>
<td>4</td>
<td>MATH 6A</td>
<td>4</td>
<td>MATH 6B</td>
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<tr>
<td>ME 14</td>
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<td>ME 6</td>
<td>4</td>
<td>ME 16</td>
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<tr>
<td>ME 17</td>
<td>3</td>
<td>ME 15</td>
<td>4</td>
<td>G.E.</td>
<td>8</td>
</tr>
<tr>
<td>PHYS 3</td>
<td>3</td>
<td>PHYS 4</td>
<td>3</td>
<td></td>
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<tr>
<td>PHYS 3L</td>
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<td><strong>TOTAL</strong></td>
<td>15</td>
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</table>

## JUNIOR YEAR

<table>
<thead>
<tr>
<th>FALL</th>
<th>units</th>
<th>WINTER</th>
<th>units</th>
<th>SPRING</th>
<th>units</th>
</tr>
</thead>
<tbody>
<tr>
<td>ME 103</td>
<td>4</td>
<td>MATRL 101(^\wedge) or</td>
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<td>ME 104</td>
<td>4</td>
</tr>
<tr>
<td>ME 107</td>
<td>3</td>
<td>MATRL 100B(^2)</td>
<td></td>
<td>ME 153</td>
<td>3</td>
</tr>
<tr>
<td>ME 151A</td>
<td>4</td>
<td>ME 108</td>
<td>3</td>
<td>Specialization Course</td>
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<tr>
<td>ME 152A</td>
<td>4</td>
<td>ME 151B</td>
<td>4</td>
<td>G.E.</td>
<td>4</td>
</tr>
<tr>
<td>MATRL 100A(^2)</td>
<td>3</td>
<td>Specialization Course</td>
<td>3</td>
<td>MATRL 100C(^\wedge)</td>
<td>3</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td>15/18</td>
<td></td>
<td>13</td>
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<td>14/17</td>
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## SENIOR YEAR

<table>
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<th>units</th>
<th>SPRING</th>
<th>units</th>
</tr>
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<tbody>
<tr>
<td>ME 154, ME 157, or ME 167(^3)</td>
<td>3</td>
<td>ME 156B</td>
<td>3</td>
<td>ME 189C</td>
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<tr>
<td>ME 105</td>
<td>4</td>
<td>ME 189B</td>
<td>3</td>
<td>Departmental Elective</td>
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<tr>
<td>ME 156A</td>
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<td>Departmental Elective</td>
<td>3</td>
<td>G.E. or Free Electives</td>
<td>8</td>
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<tr>
<td>ME 189A</td>
<td>3</td>
<td>G.E. or Free Electives</td>
<td>4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Departmental Elective</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td>16</td>
<td></td>
<td>13</td>
<td></td>
<td>14</td>
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\(^1\) ME 12S is offered every Fall, Winter, and Spring quarter. The ME 12S requirement must be finished before the start of the third year.

\(^2\) If applying to the BS/MS Materials program, juniors must take the MATRL 100A in Fall, MATRL 100B in Winter, and MATRL 100C in Spring.

\(^3\) Course availability may vary. If using ME 154, ME 157, or ME 167 to satisfy requirement, students may not count the course as an Engineering Elective. If either of the other courses are also taken, those additional courses will count as an engineering elective.

\(^\wedge\) Students may only count one course toward the major. (MATRL 101 or MATRL 100C)
**Additional Resources and Information**

Gaucho On-Line Data (GOLD) – grades, class registration, progress checks—[https://my.sa.ucsb.edu/gold](https://my.sa.ucsb.edu/gold)

UMAIL – campus email for official notifications—[http://www.umail.ucsb.edu](http://www.umail.ucsb.edu)

Schedule of Classes information – quarterly calendar and information—[http://www.registrar.ucsb.edu](http://www.registrar.ucsb.edu)

General Catalog for UCSB – academic requirements for all campus majors—[http://my.sa.ucsb.edu/Catalog/](http://my.sa.ucsb.edu/Catalog/)

Summer Sessions – Summer programs and course offerings—[http://www.summer.ucsb.edu](http://www.summer.ucsb.edu)

Tutoring – course-specific tutoring and academic skills development—[http://www.clas.ucsb.edu](http://www.clas.ucsb.edu)

Education Abroad Program – EAP options for engineering students—email: eap@engineering.ucsb.edu

College Honors Program – program information and opportunities—email: honors@engineering.ucsb.edu

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**Advising Staff**

**College Advisors:** general education requirements, academic standing, final degree clearance

**Departmental Advisors:** course selection, class enrollment, change of major, academic requirements

<table>
<thead>
<tr>
<th>College Advising staff</th>
<th>Phone</th>
<th>Email</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(805) 893-2809</td>
<td><a href="mailto:coe-info@engr.ucsb.edu">coe-info@engr.ucsb.edu</a></td>
<td>Harold Frank Hall, Rm. 1006</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Departmental Advisors:</th>
<th>Phone</th>
<th>Email</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chemical Engineering</td>
<td>893-8671</td>
<td><a href="mailto:cheugrads@engr.ucsb.edu">cheugrads@engr.ucsb.edu</a></td>
<td>Engr.II, Rm. 3357</td>
</tr>
<tr>
<td>Computer Engineering</td>
<td>893-8292</td>
<td><a href="mailto:ugrad-advisor@ece.ucsb.edu">ugrad-advisor@ece.ucsb.edu</a></td>
<td>Trailer 380, Rm. 101</td>
</tr>
<tr>
<td>Computer Science</td>
<td>893-4321</td>
<td><a href="mailto:ugradhelp@cs.ucsb.edu">ugradhelp@cs.ucsb.edu</a></td>
<td>Harold Frank Hall, Rm. 2104</td>
</tr>
<tr>
<td>Electrical Engineering</td>
<td>893-8292</td>
<td><a href="mailto:ugrad-advisor@ece.ucsb.edu">ugrad-advisor@ece.ucsb.edu</a></td>
<td>Trailer 380, Rm. 101</td>
</tr>
<tr>
<td>Mechanical Engineering</td>
<td>893-8198</td>
<td><a href="mailto:meugrad@engr.ucsb.edu">meugrad@engr.ucsb.edu</a></td>
<td>Engr.II, Rm. 2355</td>
</tr>
<tr>
<td>Technology Management</td>
<td>893-2729</td>
<td><a href="mailto:advising@tmp.ucsb.edu">advising@tmp.ucsb.edu</a></td>
<td>Phelps 2219</td>
</tr>
</tbody>
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**Academic Integrity**

The UCSB Student Conduct Code exists to support the highest standards of social and academic behavior and ensure and environment conducive to student learning. It is expected that students attending the UCSB understand and subscribe to the ideal of academic integrity, and are willing to bear individual responsibility for their work. Any submission that fulfills an academic requirement must represent a student's original work. Any act of academic dishonesty will subject a person to University disciplinary action.


- Instructor Responsibilities and Procedures: [https://senate.ucsb.edu/bylaws-and-regulations/](https://senate.ucsb.edu/bylaws-and-regulations/) (Section 10, Reg. 90)

Academic dishonesty includes cheating, plagiarism, unauthorized collaboration, furnishing false information, and misuse of course materials. Definitions and misconduct are posted at [http://studentconduct.sa.ucsb.edu/academic-integrity](http://studentconduct.sa.ucsb.edu/academic-integrity).

**A specific note about student collaboration:** Collaboration on homework assignments (i.e., problem sets), especially in light of the recognized pedagogical benefit of group study, is dictated by standards that can and do vary widely from course to course and instructor to instructor. The use of old solution sets and published solution guides presents a similar situation. Because homework assignments serve to functions – helping students learn the material and helping instructors evaluate academic performance – it is usually not obvious how much collaboration or assistance from commonly-available solutions, if any, the instructor expects. It is therefore imperative that students and instructors play an active role in communicating expectations about the nature and extent of collaboration or assistance from materials that is permissible or encouraged.
Notes