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Glenn Beltz, Associate Dean for Undergraduate Studies
Peter Allen, Publications Director
Terri Ryan Coleman, Editor

The information in this announcement supersedes that in the ***General Catalog.*** All announcements herein are subject to revision without notice.

This publication is available electronically at:
www.engineering.ucsb.edu/current_undergraduates/

College of Engineering
D I R E C T O R Y

Acting Dean: **Larry A. Coldren**
Associate Dean for Undergraduate Studies: **Glenn E. Beltz**
Associate Dean for Advancement and Planning: **Kevin Almeroth**
Associate Dean for Research: **Francis J. Doyle**
Associate Dean for Technology Management Programs: **Gary Hansen**

Office of Undergraduate Studies: Harold Frank Hall, Room 1006, (805) 893-2809
MESA Programs: (805) 893-8347
Dean's Office: Harold Frank Hall, Room 1038, (805) 893-4802
Web site: www.engineering.ucsb.edu

Undergraduate Students

The College of Engineering offers undergraduate degree programs in five disciplines: chemical engineering, computer engineering, computer science, electrical engineering, and mechanical engineering. Undergraduate applicants and students should direct all questions regarding programs and enrollment to the Office of Undergraduate Studies.

Graduate Students

Information regarding graduate programs offered in the College of Engineering may be obtained from the individual departments listed at right. The mailing address of each department is: Graduate Advisor, Name of Department, University of California, Santa Barbara, CA 93106.

General Catalog

The UC Santa Barbara General Catalog may be downloaded as a pdf file at: www.registrar.ucsb.edu and is available for purchase at www.ucsbstuff.com/

Graduate Degree Programs

Department	*Telephone (area code 805)*	*Web*
Chemical Engineering	893-8671	www.chemengr.ucsb.edu
Computer Science	893-4322	www.cs.ucsb.edu
Electrical and Computer Engr.	893-3114	www.ece.ucsb.edu
Materials	893-4601	www.materials.ucsb.edu
Mechanical Engineering	893-2239	www.me.ucsb.edu

UNIVERSITY OF CALIFORNIA, SANTA BARBARA MISSION STATEMENT

The University of California, Santa Barbara is a leading research institution that also provides a comprehensive liberal arts learning experience. Because teaching and research go hand in hand at UC Santa Barbara, our students are full participants in an educational journey of discovery that stimulates independent thought, critical reasoning, and creativity. Our academic community of faculty, students, and staff is characterized by a culture of interdisciplinary collaboration that is responsive to the needs of our multicultural and global society. Our commitment to public service is manifested through the creation and distribution of knowledge that advances the well-being of our state, nation, and world. All of this takes place within a living and learning environment like no other, as we draw inspiration, opportunity, and advantage from the beauty and resources of UC Santa Barbara's extraordinary location at the edge of the Pacific Ocean.

ACCREDITATION

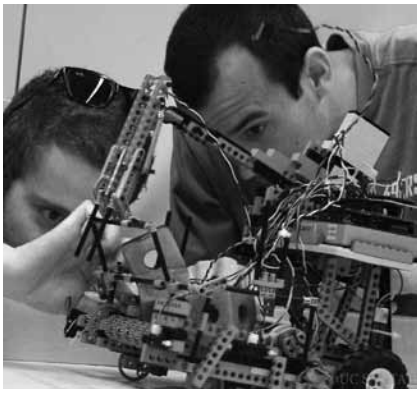
The University of California, Santa Barbara is fully accredited by the Accrediting Commission for Senior Colleges and Universities, Western Association of Schools and Colleges, 985 Atlantic Ave., Suite 100, Alameda, California 94501, (510) 748-9001. Accreditation documents are available for review in the Office of the Executive Vice Chancellor, Cheadle Hall 5105A.

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, pregnancy[1], 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: Ricardo A. Alcaîno, Director, Office of Equal Opportunity, Telephone: (805) 893-2701.

[1] Pregnancy includes pregnancy, childbirth, and medical conditions related to pregnancy or childbirth.



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Message from the Associate Dean

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 group of faculty at the top of their fields. 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 five Nobel Prize winners on this campus, four 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 1,200 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 in 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

College of Engineering

The College of Engineering at UCSB is noted for its excellence in teaching, research, and service to the community. The college has an enrollment of approximately 1,200 undergraduate students and 700 graduate students with a full-time, permanent faculty of 138. This results in an excellent student to faculty ratio and a strong sense of community in the college.

Our laboratory facilities, both departmental and in our research centers, are state-of-the-art, and most are available to undergraduate as well as graduate students. UCSB has an unusually high proportion of undergraduates who are actively involved in faculty-directed research and independent study projects. The college offers the bachelor of science degree in five disciplines: chemical engineering, computer engineering, computer science, electrical engineering, and mechanical engineering. Graduate degree programs are available in: chemical engineering, computer science, electrical and computer engineering, materials, and mechanical engineering. The undergraduate programs in chemical, electrical, and mechanical engineering are accredited by the Engineering Accreditation Commission of ABET, 111 Market Place, Suite 1050, Baltimore, MD 21202-4012 – telephone (410) 347-7700. The computer science bachelor of science program is accredited by the Computing Accreditation Commission of ABET, 111 Market Place, Suite 1050, Baltimore, MD 21202-4012 – telephone (410) 347-7700. The Computer Engineering Program is not accredited by a Commission of ABET.

The curriculum for the bachelor of science degree is designed to be completed in four years. Completion of the four-year program provides students with the background to begin professional careers or to enter graduate programs in engineering or computer science, or professional schools of business, medicine, or law. Our curricula are specifically planned to retain both of these options and to assure that our graduates are equally well prepared to enter industry and graduate study. The college and the university offer a wide variety of career counseling and job placement services.

The Office of Undergraduate Studies in Harold Frank Hall, Room 1006, provides academic advising for all undergraduates in the college. Faculty and academic advisors for the individual majors are also provided by the respective departments. This publication contains detailed information about the various programs and schedules and is published yearly. Copies may be obtained by writing to the College of Engineering, Harold Frank Hall, Room 1006, University of California, Santa Barbara, California 93106-5130. Alternatively, it is available on the web at: www.engineering.ucsb.edu/current_undergraduates

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 individualized work in regular courses and, in later years, as members of research teams. Students in the honors Program will be provided opportunities to become peer mentors and tutors within the College.

Participation in the Honors Program offers preferential enrollment in classes for continuing students as well as graduate student library privileges. Housing is available to eligible first-year students in Scholars' Halls located in several university-owned residence halls.

The College of Engineering invites approximately the top 10% of incoming freshmen into the Honors Program based on a combination of high school GPA and SAT or ACT scores. (Please note: eligibility criteria are subject to change at any time.) Transfer students with a UC transferable GPA of 3.6 or greater are invited to join the College Honors Program. Students who do not enter the College of Engineering with honors at the freshman level may petition to enter the program after attaining a cumulative GPA of 3.5 or greater after two regular quarters at UCSB.

Graduating with Honors Program Designation and to be listed as such in the Commencement Book, students must complete 6.0 total Honors units during their junior and senior years; comprised of coursework from departmental 196, 197, 199 or graduate level courses with grades of B or higher, complete a total of 10 hours of community service 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 3.5 grade-point average for the quarter and have completed a program of 12 or more letter-graded units. (Grades of Incomplete or Not Passed automatically disqualify students for eligibility for Dean's Honors.) The Dean's Honors List is posted quarterly, and 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. Graduate 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 Institute of Chemical Engineers
- American Society of Mechanical Engineers
- Association for Computing Machinery
- Engineering Student Council
- Engineers without Borders
- Institute of Electrical and Electronics Engineers
- Los Ingenieros (Mexican-American Engineering Society/Society of Hispanic Professional Engineers)
- National Society of Black Engineers
- Society for Advancement of Chicano and Native Americans in Science
- Society of Women Engineers
- Student Entrepreneurship Association
- Women in Science and Engineering

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 (see below).

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 unless they can demonstrate that they will be able to complete all the degree requirements for the proposed program without exceeding 215 total units.

Chemical Engineering. Before petitioning for a change of major to chemical engineering, students must have an overall UCSB grade point average of at least 3.0, and satisfactory completion of the following courses or their equivalents: Mathematics 3A-B-C; Chemistry 1A-AL or 2A-2AC, 1B-BL or 2B-2BC, 1C-1CL or 2C-2CC; Engineering 3; Physics 1-2. Only a limited number of petitions will be approved, and selection for entry into the major will be based on UC grade point averages and applicable courses completed.

Computer Engineering. Students may petition to enter the Computer Engineering pre-major at any time Option 1 below has been met, or they may petition to enter the full major when the requirements in Option 2 have been met.

Option 1:

1. An overall UCSB grade point average of at least 3.0; AND
2. Satisfactory completion at UCSB of at least four core classes required as preparation for the Computer Engineering major with a grade point average of at least 3.0 in all core classes completed. The core classes are Mathematics 3A, 3B, 3C, 5A; Computer Science 16, 24, 32, 40; Electrical and Computer Engineering 2A, 2B, 2C, 15A, 15B. Once approved for the Computer Engineering pre-major, the student must meet the requirements for advancing to the full major.

Option 2:

1. An overall UCSB grade point average of at least 3.0; AND
2. Satisfactory completion at UCSB of at least six of the core classes with a grade point average of at least 3.0. If the student has not attained the minimum 3.0 grade point average with the first six core classes completed, all core classes subsequently completed will be included in the grade point average computation; OR
3. Satisfactory completion of all thirteen core classes with a University of California grade point average of at least 2.75.

Computer Science. Students planning to enter the pre-computer science program must complete at least 16 units of pre-major coursework at UCSB, including 8 units in computer science, with at least a 3.0 grade point average for all pre-major courses completed with the University of California. Students who have completed the entire computer science pre-major with at least a 2.75 University of California grade point average will be admitted to full major standing upon petition whether or not they have been officially declared pre-majors. Petitions for changing to the pre-computer science or computer science majors may be filed any time upon meeting the above requirements.

Electrical Engineering. Students may petition to enter the Electrical 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 at least five classes, including at least two mathematics classes, from the following: Mathematics 5A-B-C, ECE 2A-B-C, ECE 15A. The calculation of the minimum GPA will be based on all classes completed from this list at the time of petitioning.

Mechanical Engineering. Before petitioning for a change of major to mechanical engineering, six (6) of the following core courses or their equivalents must be completed: Math 3A-B-C; Math 5A-B-C; Physics 1-2; ME 14-15 (at least one of the 6 courses must include ME 14 or ME 15). Acceptance into the major will be based on UC grade point averages and applicable courses completed.

Degree Requirements

To be eligible for a bachelor of science degree from the College of Engineering, a student must meet two sets of requirements: university degree requirements and college degree requirements.

University Degree 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 in the *UCSB General Catalog.*

College Undergraduate Degree Requirements

All undergraduate students must satisfy the preparation for the major, the major, the general education, and scholarship requirements. Preparation for the major and the major requirements for each program offered by the College of Engineering appear in subsequent sections of this catalog.

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 and International Baccalaureate Examination 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 this credit to the General Education requirements, are presented in the chart on page 7.

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 completing the International Baccalaureate (IB) diploma with a score of 30 or above will receive 30 quarter units total toward their UC undergraduate degree. The university grants 8 quarter units for certified IB Higher Level examinations on which a student scores 5, 6, or 7. The university does not grant credit for standard level exams. The application of this credit to the General Education requirements and course equivalents for these exams are listed in the *UCSB General Catalog.*

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 will be placed on academic probation if the total number of units passed at UCSB is fewer than that 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 dean of engineering to deviate from these requirements. Approval normally will be granted only in the case of medical disability, severe personal problems, or accident.

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.

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

Computer Engineering. A combined B.S./M.S. program in Computer Engineering provides an opportunity for outstanding undergraduates to earn both degrees in five years. The M.S. degree will be earned in either the Department of Computer Science or the Department of Electrical and Computer Engineering, while the B.S. degree is earned in Computer Engineering. Additional information about this program is available from the Undergraduate Studies Office and interested students should contact the Office early in their junior year, because the junior year class schedule will be different from other undergraduates. Transfer students should notify the Office of their interest in the program at the earliest possible opportunity. 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

College Board Advanced Placement Credit/General Education Program

Advanced Placement Exam with score of 3, 4, or 5	Units awarded	General Education course credit	UCSB course equivalent *(You may not enroll in these courses for credit at UCSB)*
Art History	8	F: 1 course	Art History 1
*Art Studio 2D Design Portfolio	8	none	Art Studio 18
*Art Studio 3D Design Portfolio	8	none	
*Art Studio Drawing Portfolio	8	none	
Biology	8	C: 1 course	EEMB 20, MCDB 20, Natural Science 1C
Chemistry	8	C: 1 course#	Natural Science 1B
Chinese Language & Culture			
With score of 3	8	B	
With score of 4	8	B	
With score of 5	8	B	
Comparative Government and Politics	4	D: 1 course	
+Computer Science A	2	none	
+Computer Science AB	4	C: 1 course#	Computer Science 5NM
Economics – Macroeconomics	4	D: 1 course	
Economics – Microeconomics	4	D: 1 course	
*English – Composition and Literature or Language and Composition			
With score of 3	8	Entry Level Writing Req.	Writing 1, 1E, 1LK
With score of 4	8	Writing 2	Writing 1, 1E, 1LK, 2, 2E, 2LK
With score of 5	8	Writing 2, 50	Writing 1, 1E, 1LK, 2, 2E, 2LK, 50, 50E, 50LK
Environmental Science	4	C: 1 course	Environmental Studies 2
European History	8	E: 1 course	no equivalent
French Language			
With score of 3	8	B	French 1-3
With score of 4	8	B	French 1-4
With score of 5	8	B	French 1-5
French Literature			
With score of 3	8	B	French 1-5
With score of 4 or 5	8	B	French 1-6
German Language			
With score of 3	8	B	German 1-3
With score of 4 or 5	8	B	German 1-4
Human Geography	4	none	no equivalent
Italian Language & Culture			
With score of 3	8	B	Italian 1-3
With score of 4	8	B	Italian 1-5
With score of 5	8	B	Italian 1-6
Japanese Language & Culture			
With score of 3	8	B	
With score of 4	8	B	
With score of 5	8	B	
Latin: Vergil	4	B	Latin 1-3
Latin: Literature	4	B	Latin 1-3
*•Mathematics – Calculus AB (or AB subscore of BC exam)	4	C: 1 course#	Mathematics 3A, 15, 34A, or equivalent
*†Mathematics – Calculus BC	8	C: 2 courses	Mathematics 3A, 3B, 15, 34A, 34B, or equivalent
Music – Theory	8	F: 1 course	Music 11
*Physics – B	8	C: 1 course#	Physics 10, Natural Science 1A
*Physics – C (Mechanics)	4	C: 1 course#	Physics 6A
*Physics – C (Electricity & Magnetism)	4	C: 1 course#	Physics 6B
Psychology	4	D: 1 course	Psychology 1
Spanish Language			
With score of 3	8	B	Spanish 1-3
With score of 4	8	B	Spanish 1-4
With score of 5	8	B	Spanish 1-5
Spanish Literature			
With score of 3	8	B	Spanish 1-5
With score of 4 or 5	8	B	Spanish 1-6
Statistics	4	C: 1 course#	Communication 87, EEMB 30, Geography 17 PSTAT 5AA-ZZ, Psychology 5, Sociology 3
U.S. Government and Politics	4	D: 1 course	Political Science 12
U.S. History	8	D: 1 course	no equivalent
World History	8	none	no equivalent

* A maximum of 8 units EACH in art studio, English, mathematics, and physics is allowed.
\# Also satisfies the quantitative relationship requirement in Area C.
\+ Maximum credit for computer science exams is 4 units.
† Consult the mathematics department about optional higher placement in calculus.
• If you received a score of 5 on Mathematics-Calculus AB, see www.math.ucsb.edu/ugrad/placement.php

and units of coursework as described in the *UCSB General Catalog.*

Computer Science. A combined B.S./M.S. 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 program assistant or online at www.cs.ucsb.edu/programs/undergrad/bsms/cs.shtml. Interested students may apply after completing at least 3 but no more than 8 upper division computer science courses. 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.

Electrical Engineering. A combined B.S./M.S. program in Electrical Engineering provides an opportunity for outstanding undergraduates to earn both degrees in five years. Interested students should contact the Office of Undergraduate Studies early in the junior year, because the junior year class schedule will be different from other undergraduates. Transfer students should notify the Office of their interest in the program at the earliest opportunity. 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.

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.

B.S./M.A. Program with Economics. A program which combines a B.S. in any engineering major (including computer science) with a master of arts in economics with an emphasis in business economics provides an opportunity for outstanding engineering undergraduates to earn both degrees in five years. Information about this program is available in the College of Engineering Undergraduate Studies Office or from the Department of Economics. Interested students should inform the Undergraduate Office of their interest in the program at the end of the sophomore year in order to plan their upper-division classes differently from other engineering undergraduates. After completing undergraduate degree requirements in an engineering program, students in this joint program must fulfill master's degree requirements for the degree in economics.

Policy on Academic Conduct

It is expected that all students in the College of Engineering, as well as those who take courses within the College, understand and subscribe to the ideal of academic integrity. To provide guidance on this, the College of Engineering has adopted a policy on expected academic conduct, a full copy of which appears below. As an example, it is not acceptable by default to work collaboratively on a homework assignment. In computer programming courses, a mere preliminary discussion of an assignment can lead to similarities in the final program that are detectable by sophisticated plagiarism detection software (see http://www.cs.berkeley.edu/~aiken/moss.html).

Instructors who have established that academic misconduct has occurred in their class have a variety of options at their disposal, which range from allowing the student to redo the work and/or assigning a failing grade to referring the case to the UCSB Judicial Affairs Office for either a letter of warning or a formal hearing before the Student-Faculty Committee on Student Conduct. Instructors are encouraged to discuss these remedies in further detail with the Associate Dean for Undergraduate Studies in the College of Engineering. Moreover, students who have been suspended because of academic misconduct charges are encouraged to work with the College of Engineering Undergraduate Office to develop an amended schedule that will permit the timeliest possible completion of a degree program.

College of Engineering Policy

The College of Engineering's Academic Conduct Policy is compatible with that of the University of California, in that it is expected that students understand and subscribe to the ideal of academic integrity, and are willing to bear individual responsibility for their work. Any work (written or otherwise) submitted to fulfill an academic requirement must represent a student's original work. Any act of academic dishonesty, such as cheating or plagiarism, will subject a person to University disciplinary action.

Cheating is defined by UCSB as the use, or attempted use, of materials, information, study aids, or services not authorized by the instructor of the course. The College of Engineering interprets this to include the unauthorized use of notes, study aids, electronic or other equipment during an examination or quiz; copying or looking at another individual's examination or quiz; taking or passing information to another individual during an examination or quiz; taking an examination or quiz for another individual; allowing another individual to take one's examination; stealing examinations or quizzes. Students working on take-home exams or quizzes should not consult students or sources other than those permitted by the instructor.

Plagiarism is defined by UCSB as the representation of words, ideas, or concepts of another person without appropriate attribution. The College of Engineering expands this definition to include the use of or presentation of computer code, formulae, ideas, or research results without appropriate attribution.

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 two 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.

Expectations of Members of the College Academic Community

In their classes, faculty are expected to (i) announce and discuss specific problems of academic dishonesty that pertain particularly to their classes (e.g., acceptable and unacceptable cooperation on projects or homework); (ii) act reasonably to prevent academic dishonesty in preparing and administering academic exercises, including examinations, laboratory activities, homework and other assignments, etc.; (iii) act to prevent cheating from continuing when it has been observed or reported to them by students, chairs, or deans; and, (iv) clearly define for students the maximum level of collaboration permitted for their work to still be considered individual work.

In their academic work, students are expected to (i) maintain personal academic integrity; (ii) treat all exams and quizzes as work to be conducted privately, unless otherwise instructed; (iii) take responsibility for knowing the limits of permissible or expected cooperation on any assignment.

Chemical Engineering

Department of Chemical Engineering,
Engineering II, Room 3357;
Telephone (805) 893-3412
Web site: www.chemengr.ucsb.edu

Chair: Michael Doherty
Vice-Chairs: Dale Seborg and Susannah Scott

Faculty

Bradley Chmelka, Ph.D., UC Berkeley, Professor (self-assembled materials, heterogeneous catalysis, surfactants and polymers, porous and composite solids, , magnetic resonance)

Patrick S. Daugherty, Ph.D., University of Texas at Austin, Associate Professor (protein engineering and design, combinational molecular biology, gene targeting, viral vector engineering)

Michael F. Doherty, Ph.D., Cambridge University, Professor (process design and synthesis, separations, crystal engineering)

Francis J. Doyle III, Ph.D., California Institute of Technology, Mellichamp Professor of Process Control (process control, systems biology, nonlinear dynamics)

Glenn Fredrickson, Ph.D., Stanford University, Professor (polymer theory, block copolymers, phase transitions, statistical mechanics, glass transitions, composite media)

Michael J. Gordon, Ph.D., California Institute of Technology, Assistant Professor (surface physics, scanning probe microscopy, nanoscale materials, plasmonics, laser spectroscopy)

Jacob Israelachvili, Ph.D., University of Cambridge, Professor (surface and interfacial phenomena, adhesion, colloidal systems, surface forces, bio-adhesion, friction) *1

Edward J. Kramer, Ph.D., Carnegie Mellon University, Professor (microscopic fundamentals of fracture polymers, diffusion in polymers, and polymer surfaces, interfaces and thin films) *1

L. Gary Leal, Ph.D., Stanford University, Schlinger Distinguished Professor in Chemical Engineering (fluid mechanics, physics of complex fluids, rheology)

Glenn E. Lucas, Ph.D., Massachusetts Institute of Technology, Professor (structural materials, mechanical properties) *2

Eric McFarland, Ph.D., Massachusetts Institute of Technology, M.D., Harvard , Professor (energy production, catalysis, reaction engineering, charge and energy transfer)

Samir Mitragotri, Ph.D., Massachusetts Institute of Technology, Professor (drug delivery and diagnostics, bio-membrane transport, membrane biophysics, biomedical ultrasound)

Baron G. Peters, Ph.D., UC Berkeley, Assistant Professor (molecular simulation, chemical kinetics, catalytic reaction mechanisms, nucleation, electron transfer)

Susannah Scott, Ph.D., Iowa State University, Professor (heterogeneous catalysis, surface organometallic chemistry; analysis of electronic structure and stoichiometric reactivity to determine catalytic function) *3

Dale E. Seborg, Ph.D., Princeton University, Professor (process dynamics and control, monitoring and fault detection, system identification)

M. Scott Shell, Ph.D. Princeton, Assistant Professor (molecular simulation, statistical mechanics, complex materials, protein biophysics)

Todd M. Squires, Ph.D., Harvard, Assistant Professor (fluid mechanics, microfluidics, microrheology, complex fluids)

Theofanis G. Theofanous, Ph.D., University of Minnesota, Professor, Center for Risk Studies and Safety Director (transport phenomena in multiphase systems, risk analysis) *2

Matthew V. Tirrell, Ph.D., University of Massachusetts, Auhll Professor (bioengineering, polymer science and engineering) *1

Joseph Zasadzinski, Ph.D., University of Minnesota, Professor (surface and interfacial phenomena, high resolution microscopy, biomaterials)

*1 Joint appointment with the Department of Materials.
*2 Joint appointment with the Department of Mechanical Engineering.
*3 Joint appointment with the Department of Chemistry and Biochemistry.

Emeriti Faculty

Sanjoy Banerjee, Ph.D., University of Waterloo, Professor (transport processes, multiphase systems, process safety) *2

Owen T. Hanna, Ph.D., Purdue University, Professor Emeritus (theoretical methods)

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 (transport of mass, energy, and momentum; separation processes)

Affiliated Faculty

Song-I Han, Ph.D. (Chemistry)

George M. Homsy, Ph.D. (Mechanical Engineering)

Frederick F. Lange, Ph. D. (Materials)

G. Robert Odette, Ph.D. (Materials, Mechanical Engineering)

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.

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.

Educational Objectives for the Undergraduate Program

- We expect our graduates to become innovative, competent, contributing engineers in the process industries.
- We expect our graduates to demonstrate their flexibility and adaptability in the workplace, so that they remain effective engineers, take on new responsibilities, and assume leadership roles.
- We expect at least an average of 15% of our graduates to continue their education by obtaining advanced degrees.

Program Outcomes

Upon graduation, graduates of the Chemical Engineering program at UCSB are expected to have:

1. Fundamentals – the fundamental knowledge of mathematics, computing, science, and engineering needed to practice chemical engineering and the ability to apply this knowledge to identify, formulate, and solve chemical engineering problem;
2. Laboratory – the ability to design and conduct experiments and to analyze and interpret data;
3. Design – the ability to design a system, component, or process to meet desired specifications; ability to use modern engineering tools necessary for engineering practice;
4. Advanced Training – beyond the basic fundamentals in at least one area of chemical engineering as preparation for a continuing process of lifelong learning;
5. Teamwork/Communication – the ability to function productively in multidisciplinary teams working towards common goals; the ability to communicate effectively through written reports and oral presentations;
6. Engineering & Society – the broad education necessary to understand the impact of engineering solutions in a global/societal context; a knowledge of contemporary issues; an understanding of professional and ethical responsibility; a recognition of the need for and the ability to engage in lifelong learning.

Degree Programs

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 Engineering Accreditation Commission of ABET, 111 Market Place, Suite 1050, Baltimore, MD, 21202-4012 – telephone: (410) 347-7700.

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. Graduate students are assigned a thesis advisor in the area of their research interest. 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.

Several publications are available from the department office describing the undergraduate and graduate programs.

Undergraduate Program

Note: Schedules should be planned to meet both General Education and major requirements. Detailed descriptions of these requirements are presented in the College of Engineering Announcement and General Education booklet.

A minimum of 194 units is required for graduation.

Bachelor of Science—Chemical Engineering

Preparation for the major

Engineering 3, Chemical Engineering 1A, 10; Chemistry 1A-B-C or 2A-B-C, 1AL-BL-CL or 2AC-BC-CC, 6AL-BL, 109A-B-C; Mathematics 3A-B-C, 5A-B-C, and Physics 1, 2, 3, 4, and 3L, 4L.

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.

Upper-division major

Seventy-eight upper-division units are required of which sixty-six are specified: Chemical Engineering 110A-B, 119, 120A-B-C, 128, 132A-B-C, 140A-B, 152A, 170, 180A-B, 184A-B; Chemistry 113B-C; Materials 100B or 101. Twelve 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 student's 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

1A. Engineering and the Scientific Method
(1) STAFF

Engineering and its relationship to basic science, with specific examples from engineering practice. Analysis and synthesis of engineering education. Career opportunities for chemical engineering graduates. Seminar/discussion format with guest lecturers and current experiences/issues from students' other freshman engineering/science classes.

10. Introduction to Chemical Engineering
(3) DOYLE, GORDON

Prerequisites: Chemistry 1A-B-C; Mathematics 3A-B-C; and, Engineering 3. Chemical Engineering majors only.

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

55. Chem-E-Car Activity
(1) STAFF

Prerequisite: Chem 1C and 1CL.

Students apply chemistry and engineering knowledge to design a model-scale, chemically powered car with chemically actuated brakes. The cars represent UCSB at American Institute of Chemical Engineering meetings. Grading is based on participation, design creativity, and car performance.

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 98/99/198/199/199DC/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) ISRAELACHVILI

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

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

Fundamentals of natural and artificial biomaterials and biosurfaces 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 nonbiologists.

110A. Chemical Engineering Thermodynamics
(3) STAFF

Prerequisite: Chemical Engineering 10; Mathematics 5A; Engineering majors only.

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 equilibria.

110B. Chemical Engineering Thermodynamics
(3) STAFF

Prerequisite: Chemical Engineering 110A; Mathematics 5A; Engineering majors only.

Extension of Chemical Engineering 110A to cover mixtures and multiphase equilibrium. Liquid-vapor separations calculations are emphasized. Introduction to equations of state for mixtures.

119. Current Events in Chemical Engineering
(1) STAFF

Prerequisites: Chemical Engineering 110A-B.

Assigned readings in technical journals on current events of interest to chemical engineers. Student groups present oral reports on reading assignments pertaining to new technologies, discoveries, industry challenges, society/government issues, professional and ethical responsibilities.

120A. Transport Processes
(4) SQUIRES, ZASADZINSKI, MITAGOTRI, TIRRELL

Prerequisites: Mathematics 5A-B-C; and Physics 4.

Introductory course in conceptual understanding and mathematical analysis of problems in fluid dynamics of relevance to Chemical Engineering. Emphasis is placed on performing microscopic and macroscopic mathematical analysis to understand fluid motion in response to forces.

120B. Transport Processes
(3) STAFF

Prerequisite: Chemical Engineering 120A; Mathematics 5A-B-C and Physics 4.

Introductory course in the mathematical analysis of conductive, convective and radioactive heat transfer with practical applications to design of heat exchange equipment and use.

120C. Transport Processes
(3) STAFF

Prerequisite: Chemical Engineering 120B, Mathematics 5A-B-C and Physics 4.

Introductory course in the fundamentals of mass transfer with applications to the design of mass transfer equipment.

121. Colloids and Biosurfaces
(3) ISRAELACHVILI

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

Not open for credit to students who have completed Chemical Engінerring 102.

Basic forces and interactions between atoms, molecules, small particles and extended surfaces. Special features and interactions associated with (soft) biological molecules, biomaterials and surfaces: lipids, proteins, fibrous molecules (DNA), biological membranes, hydrophobic and hydrophilic interactions, bio-specific and non-equilibrium interactions.

124. Advanced Topics in Transport Phenomena/Safety
(3) BANERJEE, THEOFANOUS

Prerequisites: Chemical Engineering 120A-B-C or Mechanical Engineering 151A-B; and Mechanical Engineering 152A.

Same course as ME 124.

Hazard identification and assessments, runaway reactions, emergency relief. Plant accidents and safety issues. Dispersion and consequences of releases.

125. Principles of Bioengineering
(3) MITRAGOTRI

Applications of engineering to biological and medical systems. Introduction to drug delivery, tissue engineering, and modern biomedical devices. Design and applications of these systems are discussed.

128. Separation Processes
(3) SCOTT

Prerequisites: Chemical Engineering 10 and 110A-B; open to College of Engineering majors only.

Basic principles and design techniques of equilibrium-stage separation processes. Emphasis is placed on binary distillation, liquid-liquid extraction, and multicomponent distillation.

132A. Analytical Methods in Chemical Engineering
(4) DAUGHERTY, FREDRICKSON, SQUIRES

Prerequisites: Mathematics 5A-B.

Develop analytical tools to solve elementary partial differential equations and boundary value problems. Separation of variables, method of characteristics, Sturm-Liouville theory, generalized Fourier analysis, and computer math tools.

132B. Computational Methods in Chemical Engineering
(3) FREDRICKSON

Prerequisite: Mathematics 5A-B-C.

Numerical methods for solution of linear and nonlinear algebraic equations, optimization, interpolation, numerical integration and differentiation, initial- value problems in ordinary and partial differential equations, and boundary- value problems. Emphasis on computational tools for chemical engineering applications.

132C. Statistical Methods in Chemical Engineering
(3) SEBORG

Prerequisites: Mathematics 5A-B-C.

Probability concepts and distributions, random variables, error analysis, point estimation and confidence intervals, hypothesis testing, development of empirical chemical engineering models using regression techniques, design of experiments, process monitoring based on statistical quality control techniques.

136. Introduction to Multiphase Flows
(3) THEOFANOUS

Prerequisites: Chemical Engineering 120A-B-C, or Mechanical Engineering 151C and 152A.

Same course as ME 136.

Development from basic concepts and techniques of fluid mechanics and heat transfer, to local behavior in multiphase flows. Key multiphase phenomena, related physics. Extension of local conservation principles to usable formulations in multiphase flows. Modelling approaches. Practical examples.

138. Risk Assessment and Management
(3) THEOFANOUS

Prerequisites: Chemical Engineering 120A-B-C; or Mechanical Engineering 151B and 152A.

Same course as ME 138.

Conceptual foundations of risk and its utility for decision making. Determinism, statistical inference, and uncertainty. Formulation of safety goals and approaches to risk management. Generalized methodology and tools for assessing risks in the industrial, ecological, and public health context.

140A. Chemical Reaction Engineering
(3) MCFARLAND, SCOTT

Prerequisites: Chemical Engineering 110A and 120A-B.

Fundamentals of chemical reaction engineering with emphasis on kinetics of homogenous and heterogeneous reacting systems. Reaction rates and reaction design are linked to chemical conversion and selectivity. Batch and continuous reactor designs with and without catalysts are examined.

140B. Chemical Reaction Engineering
(3) CHMELKA, MCFARLAND

Prerequisites: Chemical Engineering 110A, 120A-B and 140A.

Thermodynamics, kinetics, mass and energy transport considerations associated with complex homogeneous and heterogeneous reacting systems. Catalysts 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) STAFF

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.

152A. Process Dynamics and Control
(4) SEBORG, DOYLE

Prerequisites: Chemical Engineering 120A-B-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) SEBORG

Prerequisite: Chemical Engineering 152A.

The theory, design, and experimental application of advanced process control strategies including feedforward 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) DOYLE

Prerequisite: Chemical Engineering 170 and Mathematics 5A-B-C.

Applications of engineering tools and methods to solve problems in systems biology. Emphasis is placed on integrative approaches that address multi-scale and multi-rate phenomena in biological regulation. Modeling, optimization, and sensitivity analysis tools are introduced.

160. Introduction to Polymer Science
(3) KRAMER

Prerequisite: Chemistry 109A-B.

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.

170. Molecular and Cellular Biology for Engineers
(3) DAUGHERTY

Prerequisite: Chemistry 109C. Not open for credit to students who have completed Ch E 172.

Introduction to molecular and cellular biology from an engineering perspective. Topics include protein structure and function, transcription, translation, post- translational processing, cellular organization, molecular transport and trafficking, and cellular models.

171. Introduction to Biochemical Engineering
(3) DAUGHERTY

Prerequisite: Chemical Engineering 170.

Introduction to biochemical engineering covering cell growth kinetics, bioreactor design,enzyme processes, biotechnologies for modification of cellular information, and molecular and cellular engineering.

180A Chemical Engineering Laboratory
(3) STAFF

Prerequisites: Chemical Engineering 110A; and Chemical Engineering 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 110A-B; and Chemical Engineering 120A-B; and, Chemical Engineering 128 and 140A.

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

Prerequisites: Chemical Engineering 110A-B; 120A-B-C; 140A; and 152A.

Application of chemical engineering principles to plant design. Conceptual design of chemical processes. Flowsheeting methods. Engineering cost principles and economic aspects.

184B. Design of Chemical Processes
(3) DOHERTY

Prerequisites: Chemical Engineering 110A-B; 120A-B-C; 140A; 152A; and Chemical Engineering 184A.

The solution to comprehensive plant design problems. Use of computer process simulators. Optimization of plant design, investment and operations.

194. Group Studies for Advanced Students
(1-4) STAFF

Prerequisites: consent of instructor. Limited to majors in the College of Engineering.

Check with department for quarters offered.

Group studies intended for small number of advanced students who share an interest in a topic not included in the regular departmental curriculum.

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

202. Biomaterials and Biosurfaces
(3) ISRAELACHVILI

Prerequisites: consent of instructor.

Same course as BMSE 202.

Recommended preparation: prior biochemistry, physical chemistry, and organic chemistry.

Fundamentals of natural and artificial biomaterials and biosurfaces 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 nonbiologists.

210A. Fundamentals and Applications of Classical Thermodynamics and Statistical Mechanics
(4) DOHERTY

Fundamental concepts in classical thermodynamics and statistical mechanics for engineering students. Establishes the framework within which problems can be solved using methodologies that start with molecular level understanding.

210B. Advanced Topics in Equilibrium Statistical Mechanics
(3) STAFF

Recommended Preparation: Recommended preparation: a course in physical chemistry.

Same course as Materials 214.

Application of the principles of statistical mechanics and thermodynamics to treat classical fluid systems at equilibrium. Topics include liquid state theory, computer simulation methods, critical phenomena and scaling principles, interfacial statistical mechanics, and electrolyte theory.

210C. Topics in Non-equilibrium Statistical Mechanics
(3) STAFF

Introduction to the non-equilibrium statistical mechanics of classical fluid systems. Topics include: time correlation functions, linear response theory, kinetic theory of gases, Brownian motion, polymer dynamics, generalized hydrodynamics, non-equilibrium thermodynamics, and kinetics of phase transformations.

210D. Principles of Modern Molecular Simulation Methods
(3) STAFF

Provides a broad overview of modern methods for computing the properties of multibody molecular systems. The course will cover: ab initio techniques, classical potential energy functions, Monte Carlo and molecular dynamics methods, free energy calculations, phase equilibria, and self- assembly/organization.

211A. Matrix Analysis and Computation
(4) STAFF

Prerequisite: consent of instructor.

Same course as Computer Science 211A, ECE 210A, Geology 251A, ME 210A and Mathematics 206A. Students should be proficient in basic numerical methods, linear algebra, mathematically rigorous proofs, and some programming language.

Graduate level-matrix theory with introduction to matrix computations. SVD's, pseudoinverses, variational characterization of eigenvalues, perturbation theory, direct and iterative methods for matrix computations.

211B. Numerical Simulation
(4) STAFF
Prerequisite: consent of instructor.
Same course as Computer Science 211B, ECE 210B, Geology 251B, ME 210B and Mathematics 206B. Students should be proficient in basic numerical methods, linear algebra, mathematically rigorous proofs, and some programming language.
Linear multistep methods and Runge-Kutta methods for ordinary differential equations: stability, order and convergence. Stiffness. Differential algebraic equations. Numerical solution of boundary value problems.

211C. Numerical Solution of Partial Differential Equations—Finite Difference Methods
(4) STAFF
Prerequisite: consent of instructor.
Same course as Computer Science 211C, ECE 210C, Geology 251C, ME 210C and Mathematics 206C. Students should be proficient in basic numerical methods,linear algebra, mathematically rigorous proofs, and some programming language.
Finite difference methods for hyperbolic, parabolic and elliptic PDE's, with application to problems in science and engineering. Convergence, consistency, order and stability of finite difference methods. Dissipation and dispersion. Finite volume methods. Software design and adaptivity.

211D. Numerical Solution of Partial Differential Equations—Finite Element Methods
(4) STAFF
Prerequisite: consent of instructor.
Same course as Computer Science 211D, ECE 210D, Geology 251D, ME 210D, and Mathematics 206D. Students should be proficient in basic numerical methods, linear algebra, mathematically rigorous proofs, and some programming language.
Weighted residual and finite element methods for the solution of hyperbolic, parabolic and elliptical partial differential equations, with application to problems in science and engineering. Error estimates. Standard and discontinuous Galerkin methods.

212. Risk Assessment and Management
(3) THEOFANOUS
Prerequisites: consent of instructor.
Same course as ME 212.
Conceptual foundations of risk and its utility for decision making. Determinism, statistical inference, and uncertainty. Formulation of safety goals and approaches to risk management. Generalized methodology and tools for assessing risks in the industrial, ecological, and public health context.

216A. Introduction to Magnetic Resonance Spectroscopy Techniques
(3) CHMELKA
Prerequisite: consent of instructor.
An introduction to magnetic resonance theory and experimental techniques, with emphasis on quantum-mechanical descriptions of basic NMR methods for solid-state applications.

216B. Advanced Methods of Magnetic Resonance with Applications to Materials Science
(3) CHMELKA
Prerequisite: consent of instructor.
This course is intended to provide an understanding of advanced methods of magnetic resonance spectroscopy and imaging, emphasizing new applications to current issues in materials research.

218. Introduction to Multiphase Flows
(3) STAFF
Prerequisite: consent of instructor.
Same course as ME 218.
Development from basic concepts and techniques of fluid mechanics and heat transfer, to local behavior in multiphase flows. Key multiphase phenomena, related physics. Extension of local conservation principles to usable formulations in multiphase flows. Modelling approaches. Practical examples. Computer simulations.

220A. Advanced Transport Processes—Laminar Flow and Convective Transport Processes
(4) LEAL
Prerequisite: consent of instructor.
Basic principles of fluid mechanics and convective transport processes. Governing equations and boundary conditions. Non-dimensionalization and scaling. Self-similar solutions and similarity transformations. Unidirectional flows. The thin gap approximation, lubrication theory and thin film dynamics. Low Reynolds number flows.

220B. Advanced Transport Processes—Laminar Flow and Convective Transport Processes
(3) LEAL
Prerequisite: consent of instructor.
Continuation of ChE 220A. Viscous flows. Application of scaling and asymptotic methods to transport problems and fluid motions; Weak convection effects; Boundary layer theories for fluid mechanics and transport processes. Introduction to Linear stability theory for interfacial and buoyancy-driven flows.

220C. Advanced Transport Processes—Mass Transfer
(3) ZASADZINSKI
Basic principles of diffusional processes, multicomponent systems, diffusion with chemical reaction, penetration and surface renewal theories, turbulent transport.

221. Turbulent Flow
(3) STAFF
Prerequisites: Chemical Engineering 220A-B or Mechanical Engineering 220A-B.
Same course as ME 223.
Nature and origin of turbulence, boundary layer mechanics law of the wall, wakes, and jets, transport of properties, statistical description of turbulence, measurement problems, stratification effects. Application of principles to practical problems is stressed.

222A. Colloids and Interfaces I
(3) ISRAELACHVILI
Prerequisite: consent of instructor.
Same course as Materials 222A and BMSE 222A.
Introduction to the various intermolecular interactions in solutions and in colloidal systems: Van der Waals, electrostatic, hydrophobic, solvation, H-bonding. Introduction to colloidal systems: particles, micelles, polymers, etc. Surfaces: wetting, contact angles, surface tension, etc.

222B. Colloids and Interfaces II
(3) ZASADZINSKI
Prerequisite: consent of instructor.
Same course as Materials 222B.
Recommended preparation: Materials 222A or Chemical Engineering 222A.
Continuation of 222A. Interparticle interaction, coagulation, flocculation, DLVO theory, steric interactions, polymer-coated surfaces, polymers in solution, viscosity in thin liquid films. Surfactant self-assembly: micelles, micro-emulsions, lamellar phases, etc. Surfactants in surfaces: Langmuir-Blodgett films, adsorption, adhesion.

226. Level Set Methods
(4) GIBOU
Prerequisite: Computer Science 211C, or Chemical Engineering 211C, or ECE 210C, or ME 210C.
Same course as CMPSC 216, ECE 226 and ME 216.
Mathematical description of the level set method and design of the numerical methods used in its implementations (ENO-WENO, Godunov, Lax-Friedrich, etc.). Introduction to the Ghost Fluid Method. Applications in CFD, Materials Sciences, Computer Vision and Computer Graphics.

230A. Advanced Theoretical Methods in Engineering
(4) CHMELKA, FREDRICKSON, LEAL, PETERS
Prerequisite: consent of instructor.
Same course as ME 244A.
Methods of solution of partial differential equations and boundary value problems. Linear vector and function spaces, generalized Fourier analysis, Sturm-Liouville theory, calculus of variations, and conformal mapping techniques.

230B. Advanced Theoretical Methods in Engineering
(3) FREDRICKSON, SQUIRES
Prerequisites: Chemical Engineering 230A and consent of instructor.
Same course as ME 244B.
Advanced mathematical methods for engineers and scientists. Complex analysis, integral equations and Green's functions. Asymptotic analysis of integrals and sums. Boundary layer methods and WKB theory.

230C. Nonlinear Analysis of Dynamical Systems
(3) DOHERTY
Prerequisites: Chemical Engineering 230A and consent of instructor.
Bifurcation and stability theory of solutions to nonlinear evolution equations; introduction to chaotic dynamics. Emphasis on asymptotic and numerical methods for the analysis of steady-state and time-dependent nonlinear boundary-value problems.

238A. Rheology of Complex Fluids
(3) STAFF
Same course as Materials 238A.
An introduction to molecular and microscale theories for the viscoelastic behavior of complex fluids: suspensions, colloidal dispersions, liquid crystals, dilute polymer solutions.

238B. Rheology of Complex Fluids
(3) STAFF
Same course as Materials 238B.
Continuation of ChE 238A: Emphasis of the second term is on concentrated systems and polymeric liquids, reptation theory and extensions of reptation theories to complex architectures in the linear viscoelastic regime. Nonlinear Rheology for polymers.

240A. Advanced Chemical Reaction Engineering
(3) MCFARLAND
Prerequisite: consent of instructor.
Following review of the theory of reaction kinetics for catalyzed and noncatalyzed systems, detailed consideration is given to design and performance of catalysts and chemical reactors. Mathematical studies of stability and optimization are emphasized in relationship to mass, energy, and momentum transport.

241. Advanced Science and Engineering of Energy Conversion
(3) MCFARLAND
The course provides a 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.

246. Advanced Catalysis
(3) MCFARLAND, SCOTT
Prerequisite: consent of instructor.
Theories of reaction rates. Heterogeneous and homogenous catalysis, including physical structure and characterization of catalysts. Catalyst poisoning.

255. Methods in Systems Biology
(3) DOYLE
Prerequisites: prior coursework in cellular biology and mathematics; consent of instructor.
Same course as BMSE 255.
Fundamentals of dynamic network organization in biology (genes, proteins, metabolites). Emphasis on mathematical approaches to model and analyze complex biophysical network systems. Detailed case studies demonstrating successes of systems biology. Basic biological systems reviewed for non-biologists.

290. Seminar
(.5) STAFF
May be repeated for credit.
Seminar featuring guest speakers and graduate students on topics of current research interest.

291. Research Group Studies
(1-2) STAFF
Prerequisite: consent of instructor.
Students or instructors present recently published papers and/or results relevant to their own research.

295. Group Studies: Controls, Dynamical

Systems, and Computation
(1) STAFF

594. Special Topics
(1-4) STAFF
Special seminar on research subjects of current interest.

596. Directed Reading and Research
(1-12) STAFF
Experimental or theoretical research undertaken under the direction of a faculty member for graduate students who have not yet advanced to candidacy.

598. Master's Thesis Research and Preparation
(1-12) STAFF
Not applicable to course requirement for master of science degree.
Only for research underlying the thesis and writing the thesis.

599. Dissertation Research and Preparation
(1-12) STAFF
Only for research underlying the dissertation and writing the dissertation.

Computer Engineering

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Director: Frederic T. Chong
Vice Director: Patrick Yue

Faculty

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

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, Professor (design automation, VLSI testing, design synthesis, design verification, algorithms)

Frederic T. Chong, Ph.D., Massachusetts Institute of Technology, Professor (computer architecture, novel computing technologies, quantum computing, embedded systems, and architectural support for system security and reliability)

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

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

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

Louise E. Moser, Ph.D., University of Wisconsin, Professor (distributed systems, computer networks, software engineering, fault-tolerance, formal specification and verification, performance evaluation)

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

Volkan Rodoplu, Ph.D., Stanford University, Associate Professor (wireless networks, energy-efficient and device-adaptive communications)

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

Luke Theogarajan, Ph.D., Massachusetts Institute of Technology, Assistant 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, Associate Professor (design verification, testing, computer-aided design of microprocessors)

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

Patrick Yue, Ph.D., Stanford University, Associate Professor (high-speed CMOS IC design, cell-based RF CAD methodology and integrated biomedical sensors)

Ben Zhao, Ph.D., University of California, Berkeley, Assistant Professor (computer/overlay/mobile networking, large-scale distributed systems, operating systems, network simulation and modeling)

Heather Zheng, Ph.D., University of Maryland, College Park, Associate Professor (wireless/mobile/ad hoc networking, cognitive radio and dynamic spectrum networks, multimedia communications, security, game theory, algorithms, network simulation and modeling)

The Computer Engineering major's objective is to educate broadly based engineers with an understanding of digital electronics, computer architecture, system software and integrated circuit design. These topics bridge traditional electrical engineering and computer science curricula. The Computer Engineering degree program is conducted jointly with faculty from the Department of Computer Science and the Department of Electrical and Computer Engineering. Computer engineers emerging from this program will be able to design and build integrated digital hardware and software systems in a wide range of applications areas. Computer engineers will seldom work alone and thus teamwork and project management skills are also emphasized. The undergraduate major in Computer Engineering prepares students for a wide range of positions in business, government and private industrial research, development and manufacturing organizations.

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. Faculty advisors are also available to help with academic program planning. Students who hope to change to this major should consult the department advisor.

The computer engineering program is not accredited by a Commission of ABET.

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.

Program Outcomes

Upon completion of this program, students will have:

1) Acquired strong basic knowledge and skills in those fundamental areas of mathematics, science, and engineering necessary to facilitate specialized professional training at an advanced level. Developed a recognition of the need for and the ability to engage in lifelong learning.
2) Experienced in-depth training in state-of-the-art specialty areas in computer engineering.
3) Benefited from hands-on, practical laboratory experiences where appropriate throughout the program. The laboratory experiences will be closely integrated with coursework and will make use of up-to-date instrumentation and computing facilities. Students will have completed both hardware-oriented and software-oriented assignments.
4) Experienced design-oriented challenges that exercise and integrate skills and knowledge acquired during their course of study. These

challenges may include design of components or subsystems with performance specifications. Graduates should be able to demonstrate an ability to design and test a system, analyze experimental results, and draw logical conclusions from them.
5) Learned to function well in multidisciplinary teams and collaborative environments. To this end, students must develop communication skills, both written and oral, through teamwork and classroom participation. Teamwork and individual originality will be evidenced through written reports, webpage preparation, and public presentations.
6) Completed a well-rounded and balanced education through required studies in selected areas of fine arts, humanities, and social sciences. This outcome provides for the ability to understand the impact of engineering solutions in a global and societal context. A required course in engineering ethics will have prepared students for making professional contributions while maintaining institutional and individual integrity.

Admission to the Major

Requirements for Advancing to the Computer Engineering Major from the Computer Engineering Pre-Major

Students intending to major in computer engineering should declare the pre-major when applying for admission to the university. It is strongly recommended that incoming freshmen with no prior programming experience take Computer Science 8 before taking Computer Science 16.

Students may petition to advance from the computer engineering pre-major to the computer engineering major when they have met either of the following requirements:

Option A: Satisfactory completion at UCSB of at least six core classes required as preparation for the computer engineering major with a grade-point-average of at least 3.0. The core classes are: Mathematics 3A, 3B, 3C, 5A; Computer Science 16, 24, 32, 40; Electrical and Computer Engineering 2A, 2B, 2C, 15A, 15B. If the student has not attained the minimum 3.0 grade-point-average with the first six core classes completed, all core classes subsequently completed will be included in the grade-point-average computation.

Option B: Satisfactory completion of all thirteen core classes with a University of California grade-point-average of at least 2.75.

Undergraduate Program

Note: Schedules should be planned to meet both General Education and major requirements. Detailed descriptions of these requirements are presented in the College of Engineering Announcement and General Education booklet.

A minimum of 189 units is required for graduation.

Bachelor of Science—Computer Engineering

The curriculum contains a core required of all computer engineers, a choice of at least 32 units of senior year elective courses including completion of two out of eight 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.

Preparation for the major

All undergraduate Computer Engineering majors are required to meet a set of minimum unit and grade-point requirements and a set of General Education requirements which are common to all undergraduate majors in the College of Engineering. In addition, required preparation for the major consists of the following lower-division courses (or their equivalents if taken elsewhere): Chemistry 1A-B or 2A-B, 1AL-BL or 2AC-BC; Computer Science 16, 24, 32, 40; ECE 2A-B-C, 15A-B; Mathematics 3A-B-C, 5A; Physics 1, 2, 3, 4, 3L, 4L.

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

Upper-division major

The upper-division requirements consist of a set of required courses and a minimum of 32 units (8 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). Upper-division courses required for the major are: Computer Science 130A, 170; ECE 152A-B, 154, 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-Aided Design (CAD): ECE 156A-B
- Computer Systems Design: ECE/CMPSC 153A, ECE 153B
- Computer Networks: ECE 155A/CMPSC 176A, ECE 155B/CMPSC 176B
- Distributed Systems: ECE 151/CMPSC 171 and one or both of the Computer Networks courses
- Programming Languages: CMPSC 160, 162
- Real-Time Computing & Control: ECE 147A-B, 157
- Multimedia: ECE 178, ECE/CMPSC 181B, ECE 160/CMPSC 182
- VLSI: ECE 124A, 124D

Satisfactory Progress and 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-C 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 16 and Electrical and Computer Engineering starting on page 23.

Computer Science

Department of Computer Science, Harold Frank Hall, Room 2104; Telephone (805) 893-4321 Web site: www.cs.ucsb.edu

Chair: Amr El Abbadi
Vice Chair: Tevfik Bultan

Faculty

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

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

Elizabeth Belding, Ph.D., University of California, Santa Barbara, Professor (mobile wireless networking, ad hoc mobile networks and protocols, and multimedia systems and performance evaluation)

Tevfik Bultan, Ph.D., University of Maryland, College Park, Professor (model checking, concurrency, web services, static analysis, software engineering)

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

Frederic T. Chong, Ph.D., Massachusetts Institute of Technology, Professor (computer architecture, novel computing technologies, quantum computing, embedded systems, and architectural support for system security and reliability)

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

C. Michael Costanzo, Ph.D., University of California, Santa Barbara, Lecturer

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

Amr El Abbadi, Ph.D., Cornell University, Professor (information systems, databases, fault-tolerant distributed systems)

Diana Franklin, Ph.D., University of California, Davis, Lecturer SOE (computer architecture, embedded systems, architectural support for reliability, undergraduate teaching methods for diverse populations)

Frederic Gibou, Ph.D., University of California, Los Angeles, Associate Professor (computational mathematics, modeling and simulations - materials science, multiphase flows; level-set methods, ghost-fluid methods, and interface problems; and image segmentation with applications to radiotherapy treatment planning and civil engineering)*2

John R. Gilbert, Ph.D., Stanford University, Professor (combinatorial scientific computing, tools and software for computational science and engineering, numerical linear algebra, smart matter and systemic MEMS, distributed sensing and control)

Teofilo Gonzalez, Ph.D., University of Minnesota, Professor (multimessage multicasting, VLSI placement and routing algorithms, scheduling theory; design and analysis of algorithms)

Ben Hardekopf, Ph.D., University of Texas at Austin, Acting Assistant Professor (programming Languages and systems)

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

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

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

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

Christopher Kruegel, Ph.D., Vienna University of Technology, Associate Professor (computer and network security, malware detection, websecurity, program analysis, operating systems)

Linda R. Petzold, Ph.D., University of Illinois at Urbana–Champaign, Professor (computational science and engineering, multiscale numerical simulation, systems biology)*2

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

Ambuj Singh, Ph.D., University of Texas at Austin, Professor (bioinformatics, databases, parallel and distributed systems)*3

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

Jianwen Su, Ph.D., University of Southern California, Professor (database systems and applications, web services)

Subhash Suri, Ph.D., Johns Hopkins University, Professor (algorithms, internet computing, computational geometry)

Matthew Turk, Ph.D., Massachusetts Institute of Technology, Professor (computer vision, human computer interaction, perceptual user interfaces, imaging systems)

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

Giovanni Vigna, Ph.D., Politecnico di Milano, Professor (computer and network security, network models and protocols, mobile code languages and systems, mobile agent security)

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

Richard Wolski, Ph.D., University of California, Davis/Livermore, Professor (distributed systems, computational grid computing, on-line performance forecasting)

Xifeng Yan, Ph.D., University of Illinois at Urbana Champaign, Assistant Professor (data mining, data management, machine learning, bioinformatics)

Tao Yang, Ph.D., Rutgers University, Professor (parallel and distributed systems, high performance scientific computing, cluster-based network services, Internet search)

Ben Zhao, Ph.D., University of California, Berkeley, Assistant Professor (large-scale distributed systems, security and privacy, overlay and peer-to-peer networks, mobile and wireless networks)

Heather Zheng, Ph.D., University of Maryland, College Park, Associate Professor (wireless/mobile/ad hoc networking, cognitive radio and dynamic spectrum networks, multimedia communications, security, game theory, algorithms, network simulation and modeling)

Emeriti Faculty

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

Marvin Marcus, Ph.D., University of California, Berkeley, Professor Emeritus (linear and multilinear algebra, scientific computation, numerical algorithms)

Roger C. Wood, Ph.D., University of California, Los Angeles, Professor Emeritus (computer system modeling, design and analysis, computer architecture)*6

*1 Joint appointment with the College of Creative Studies.
*2 Joint appointment with the Department of Mechanical Engineering.
*3 Joint appointment with the Department of Biomolecular Science and Engineering (BMSE).
*4 Joint appointment with the Department of Geography.
*5 Joint appointment with the Department of Physics.
*6 Joint appointment with the Department of Electrical and Computer Engineering

Affiliated Faculty

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

P. Michael Melliar-Smith, Ph.D. (Electrical and Computer Engineering)

Kenneth Rose, Ph.D. (Electrical and Computer Engineering)

Martin Raubal, Ph.D. (Geography)

The Department of Computer Science offers programs leading to the degrees of bachelor of arts and bachelor of science in computer science, and the M.S. and Ph.D. in computer science. The B.A. is a College of Letters and Science major; the B.S. is a College of Engineering major. The B.S. degree program in computer science is accredited by the Computing Accreditation Commission of ABET, 111 Market Place, Suite 1050, Baltimore, MD 21202-4012-telephone: (410) 347-7700.

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 majors and premajors use 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 the 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 help with academic program planning. A department publication, *Computer Science Undergraduate Brochure*, describes degree offerings and degree requirements.

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.

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. Baccalaureate graduates, ready for immediate employment, are trainable for most computer science positions in government and a wide range of industries. Outstanding graduates interested in highly technical careers, research, and/or academia, should be prepared to further their education in graduate school.

The primary computer science departmental emphasis is on 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:

a. An ability to apply knowledge of computing and mathematics appropriate to computer science.
b. An ability to analyze a problem, and identify and define the computing requirements appropriate to its solution.
c. An ability to design, implement, and evaluate a computer-based system, process, component, or program to meet desired needs.
d. An ability to function effectively on teams to accomplish a common goal.
e. An understanding of professional, ethical, and social responsibilities.
f. An ability to communicate effectively.
g. An ability to analyze the impact of computing on individuals, organizations, and society, including ethical, legal, security, and global policy issue.
h. Recognition of the need for and an ability to engage in continuing professional development.
i. An ability to use current techniques, skills, and tools necessary for computing practice.
j. 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 trade-offs involved in design choices.
k. An ability to apply design and development principles in the construction of software systems of varying complexity.

Admission to the Major

Students intending to major in computer science should declare a computer science pre-major when applying for admission to the university.

Computer Science majors and pre-majors have priority when registering in all Computer Science courses. Students who declare the computer science pre-major or major are responsible for satisfying major requirements in effect at the time of their declaration. When students have completed the required pre-major courses, they must petition to change from pre-major to major status. Students cannot be accepted into the computer science major unless they have successfully completed the computer science preparation for the major courses.

Courses required for the pre-major or major, lower- or upper-division, inside or outside of the Department of Computer Science, must be taken for letter grades.

Undergraduate Program

Computer Engineering Major

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 13.

Bachelor of Science—Computer Science

Note: Schedules should be planned to meet both General Education and major requirements. Detailed descriptions of these requirements are presented in the *College of Engineering Announcement and General Education booklet*. A minimum of 184 units is required for graduation.

Admission to the full BS major is contingent upon the prior completion of the courses listed in the preparation for the major with at least a 2.75 cumulative grade point average.

Preparation for the major—B.S.

Required: Mathematics 3A-B-C and 5A-B; Computer Science 16, 24, 32, 40, 48, 56 and 64; and Probability and Statistics 120A.

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 courses but may be counted as a free elective.

Students applying for major status in the BS program who have completed more than 105 units will **not** be considered for a change of major/change of college unless they can demonstrate that they will be able to complete all of the degree requirements for the proposed program without exceeding 215 units.

Students may petition to enter the computer science pre-major at any time **Option A** below has been met, or they may petition to enter the full major when **Option B** has been met.

Option A: Satisfactory completion at UCSB of at least four 4-unit courses required for the computer science preparation for the major, including at least two computer science courses, with a University of California grade point average of at least 3.0 in all the preparation for the major courses taken.

Option B: Satisfactory completion of all the preparation for the major requirements with a University of California grade point average of at least 2.75.

Please note: Pre-major status does not guarantee admission to major status. To be admitted to the major, the student must complete the pre-major courses with a minimum grade point average of 2.75. All courses required for the preparation for the major must be taken for a letter grade. No exceptions will be made to the minimum 2.75 GPA rule.

Upper-division major

The following courses are required: Computer Science 111 or 140, 130A-B, 138, 154, 160, 162, 170; Electrical and Computer Engineering 152A; and Probability and Statistics 120B. In addition, at least 20 units of major field electives are required. Prior approval of these electives must be obtained from the faculty advisor. In addition, the following courses are required: Engineering 101, Physics 1, 2, 3, 3L and at least 8 units of science electives. Lists of approved major field electives and science electives are available in the computer science office and on the web at: www.cs.ucsb.edu/undergraduate

Bachelor of Arts—Computer Science

The College of Letters and Science offers a bachelor of arts degree in computer science, with emphases in computational biology, computational economics, and computational geography. For information about this major, refer to the College of Letters and Science section of the *UCSB General Catalog.*

Computer Science Courses

LOWER DIVISION

1. Seminar on the Field of Computer Science
(1) FRANKLIN

Overviews the potential of, and opportunities available from, the field of computer science. Topics include an overview of how computers work and the interesting ways in which computers can be applied to solve important and high-impact technological, social, and cutting-edge research problems.

5AA-ZZ. Introduction to Computer Programming
(4) FRANKLIN

Not open for credit to students who have completed Computer Science 10 or Engineering 3. May not be repeated with a different suffix.

Introduction to programming and the organization of computers. Basic programming concepts, algorithms, data and control structures, debugging, program design, documentation, structured programming.

8. Introduction to Computer Science
(4) CONRAD, FRANKLIN

Not open for credit to students who have completed Computer Science 5, Computer Science 10, Computer Science 16, or Engineering 3.

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.

10. Computer Programming
(4) SU

Prerequisite: Mathematics 3A.

Students with no prior programming background are encouraged to take Computer Science 5JA before 10.

Introduction to programming and computers. Basic programming concepts: algorithms, data and control structures, debugging, program design, documentation, structured programming, object oriented programming.

11AA-ZZ. Programming Language Laboratory
(1) FRANKIN

Different sections may be repeated. Sections not always offered.

Recommended preparation: knowledge of at least one programming language.

A self-paced course to allow a student who already possesses a working knowledge of at least one programming language an opportunity to learn other languages of interest.

12. Programming Methods in C
(4) FRANKLIN

Prerequisites: Computer Science 5 or 10 or Engineering 3.

Not open for credit to computer science majors or pre-majors. Not open for credit to students who have completed Computer Science 11C, 22, or 60.

Introduction to the UNIX system, C programming language, and data structures. Topics include: introduction to the UNIX system, C shell and shell scripts; UNIX file system and utilities; stacks, queues, lists, and trees.

16. Problem Solving with Computers I
(4) FRANKLIN, KRINTZ

Prerequisite: Math 3A

Recommended Preparation: Students with no experience with computer programming are encouraged to take Computer Science 5 or 8 before Computer Science 16.

Not open for credit to students who have completed Computer Science 10.

Fundamental building blocks for solving problems using computers. Topics include basic computer organization and programming constructs: memory CPU, binary arithmetic, variables, expressions, statements, conditionals, iteration, functions, parameters, recursion, primitive and composite data types, and basic operating system and debugging tool.

20. Programming Methods
(4) AGRAWAL

Prerequisite: Computer Science 10 and Mathematics 3B.

Programming techniques as follows: specification, representation, and manipulation of basic data structures such as stacks, queues, lists, trees, sets, arrays, etc. Searching and sorting techniques; predicate logic and program correctness; induction and recursion; running time analysis. Students write several medium-sized object-oriented programs.

24. Problem Solving with Computers II
(4) FRANKLIN, COSTANZO

Prerequisite: Computer Science 16 or Engineering 3; and Mathematics 3B.

Not open for credit to students who have completed Computer Science 12 or 20.

Repeat Comments: Course counts as legal repeat of Computer Science 12.

Intermediate building blocks for solving problems using computers. Topics include data structures, object-oriented design and development, algorithms for manipulating these data structures and their runtime analyses. Data structures introduced include stacks, queues, lists, trees, and sets.

30. Introduction to Computer Systems
(4) ZHENG

Prerequisite: Engineering 3 or Computer Science 5AA-ZZ or 10; and, Mathematics 3C.

Not open for credit to students who have completed ECE 15 or 15B.

Basic computer organization, assembly language programming.Gates, combinational circuits, flip-flops and the design and analysis of sequential circuits.

32. Object Oriented Design and Implementation
(4) HOLLERER

Prerequisite: Computer Science 24

Not open for credit to students who have completed Computer Science 20.

Repeat Comments: Computer Science 32 is a legal-repeat for Computer Science 60

Advanced topics in object-oriented computing. Topics include encapsulation, data hiding, inheritance, polymorphism, compilation, linking and loading, memory management, and debugging; recent advances in design and development tools, practices, libraries, and operating system support.

40. Foundations of Computer Science
(4) SU

Prerequisites: Computer Science 10 or 12; and Mathematics 3C.

Propositional predicate logic, set theory, functions and relations, counting, mathematical induction and recursion (generating functions).

48. Computer Science Project
(4) CAPPELLO

Prerequisite: Computer Science 32

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 their final projects.

50. Programming Project
(4) CAPPELLO

Prerequisites: Computer Science 10 and 20.

Program design (modularization, designing for changeability, robustness, and testability), basic software engineering practices, principles of user interface design. Students design, implement, and test one or two extensive object-oriented programs.

60. Introduction to C, C++, and UNIX
(4) HOLLERER

Prerequisite: Computer Science 20.

Reduced credit of 2 units will be given to students who have completed Computer Science 12.

Syntax and semantics of C and C++. Introduction to basic UNIX utilities and tools. Students complete several small projects that exercise their understanding of the material presented in class.

64. Computer Organization and Logic Design
(4) ZHENG, FRANKLIN

Prerequisite: Engineering 3 or Computer Science 8 or Computer Science 16; and Mathematics 3C.

Not open for credit to students who have completed ECE 15 or ECE 15B or Computer Science 30.

Repeat Comments: Course counts as a legal repeat of CMPSC 30.

Assembly language programming and advanced computer organization; Digital logic design topics including gates, combinational circuits, flip-flops, and the design and analysis of sequential circuits.

95AA-ZZ. Undergraduate Seminar in Computer Science
(1-4) STAFF

Prerequisites: Open to pre-computer science and pre-computer engineering majors only; consent of instructor.

Seminars on introductory topics in computer science. These seminars provide an overview of the history, technology, applications, and impact in various areas of computer science, including: 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, J. History, N. General.

UPPER DIVISION

111. Introduction to Computational Science
(4) PETZOLD

Prerequisites: Mathematics 5B; and, Computer Science 12 or 60.

Not open for credit to students who have completed Computer Science 110A.

Introduction to computational science, emphasizing basic numerical algorithms and the informed use of mathematical software. Matrix computation, systems of linear and nonlinear equations, interpolation and zero finding, differential equations, numerical integration. Students learn and use the Matlab language.

123. Overview of Computer Systems: Hardware and Software
(4) EL ABBADI

Prerequisites: Computer Science 20 and 60.

Not open for credit to students who have completed Computer Science 30 or Computer Science 170.

Basic computer architecture: CPU, memory, I/O. Basic operating systems concepts: processes, synchronization, memory management, virtual memory, file systems.

130A. Data Structures and Algorithms I
(4) GONZALEZ

Prerequisites: Computer Science 20, 40 and 60; PSTAT 120 or ECE 139; open to computer science, computer engineering, and electrical engineering majors only.

The study of data structures and their applications. Correctness proofs and techniques for the design of correct programs. Internal and external searching. Hashing and height balanced trees. Analysis of sorting algorithms. Memory management. Graph traversal techniques and their applications.

130B. Data Structures and Algorithms II
(4) GONZALEZ

Prerequisite: 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, branch and bound, backtracking, and local search. Applications of techniques to problems from several disciplines. NP - completeness.

138. Automata and Formal Languages
(4) EGECIOGLU

Prerequisite: Computer Science 40; open to computer science and computer engineering majors only.

Not open for credit to students who have completed Computer Science 136.

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
(4) GILBERT

Prerequisites: Mathematics 5B and Computer Science 20; and, Computer Science 12 or 60.

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.

153A. Hardware/Software Interface
(4) KRINTZ

Prerequisite: Computer Science 130A with a minimum grade of C-.

Same course as ECE 153A.

The study of the structures employed at the interface of hardware and software in modern computing systems. Instruction set architecture (ISA) design trade-offs, operating system and hardware support for input/output devices (memory-mapping, interrupts, device drivers). Operating system and real-time system scheduling of tasks. Low level software and program support infrastructures (virtualization, compilation, optimization, emulation/simulation, debugging).

154. Computer Architecture
(4) SHERWOOD, CHONG

Prerequisite: ECE 152A.

Not open for credit to students who have received credit for ECE 154.

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.

160. Translation of Programming Languages
(4) SHERWOOD, BULTAN

Prerequisites: Computer Science 30 or 123; Computer Science 130A; and Computer Science 136 or 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
(4) KRINTZ

Prerequisite: Computer Science 130A; 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 mechanism; reusability through genericity and inheritance; type systems; procedural, object-oriented, functional, and logic programming languages.

165A. Artificial Intelligence
(4) TURK

Prerequisite: Computer Science 130A

Introduction to the field of artificial intelligence which attempts to understand and build intelligent systems. Topics include AI programming languages, search, knowledge representation and reasoning, planning, perception, and intelligent agents.

165B. Machine Learning
(4) SMITH

Prerequisite: Computer Science 130A.

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.

167. Introduction to Bioinformatics
(4) SINGH

Prerequisite: Computer Science 130B.

Not open to students who have completed Computer Science 190

Review of the fundamentals of molecular biology and genetics; pairwise sequence alignment: dynamic programming, database searching; multiple sequence alignment; microarray data analysis; protein structure alignment; phylogeny construction: distance and character based methods; other current topics.

170. Operating Systems
(4) AGRAWAL

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; interprocess communication and synchronization; input-output, file systems, memory management.

171. Distributed Systems
(4) EL ABBADI

Prerequisite: Computer Science 170.

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
(4) BULTAN

Prerequisites: Computer Science 130A; open to computer science majors only.

Not open for credit to students who have completed Computer Science 189A.

Recommended preparation: Computer Science 130B.

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
(4) SU

Prerequisite: Computer Science 130A.

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
(4) SU

Prerequisite: Computer Science 130B.

Queries and processing, optimizer, cost models, execution plans, rewriting rules, access methods, spatial indexing, transactions, ACID properties, concurrency control, serializability, two-phase locking, timestamping, logging, checkpointing, transaction abort and commit, crash recovery; distributed databases.

176A. Introduction to Computer Communication Networks
(4) ALMEROTH, BELDING

Prerequisites: PSTAT 120A or ECE 139; open to computer science, computer engineering, and electrical engineering majors only.

Not open for credit to students who have completed Computer Science 176 or ECE 155 or ECE 155A.

Recommended preparation: PSTAT 120B.

Basic concepts in networking, the OSI model, error detection codes, flow control, routing, medium access control, and high-speed networks.

176B. Network Computing
(4) ZHAO, VIGNA

Prerequisite: Computer Science 176A.

Not open for credit to students who have completed ECE 155B or 194W.

Focus on networking technologies used in the Internet. The OSI model is used as a guide for exploring and understanding how the Internet works. Topics include snooping packets in the network, socket programming, and implementing application-layer protocols.

176C. Advanced Topics in Internet Computing
(4) BELDING, ZHENG

Prerequisite: Computer Science 176B.

General overview of wireless and mobile networking, multimedia, security multicast, quality of service, IPv6, and web caching. During the second half of the course, one or more of the above topics are studied in greater detail.

177. Computer Security
(4) KEMMERER

Prerequisite: Computer Science 170 (may be taken concurrently).

Introduction to the basics of computer security and privacy. Analysis of technical difficulties of producing secure computer information systems that provide guaranteed controlled sharing. Examination and critique of current systems, methods, certification.

178. Introduction to Cryptography
(4) EGECIOGLU

Prerequisites: Computer Science 10 and PSTAT 120A or 121A or equivalent courses.

An introduction to the basic concepts and techniques of cryptography and cryptanalysis. Topics include: The Shannon Theory, classical systems, the Enigma machine, the data encryption standard, public key systems, digital signatures, file security.

180. Computer Graphics
(4) WANG

Prerequisite: Computer Science 130B or consent of instructor.

Overview of OpenGL graphics standard, OpenGL state machine, other 3D graphics libraries, 3D graphics pipeline, 3D transformations and clipping, color model, shading model, shadow algorithms, texturing, curves and curved surfaces, graphics hardware, interaction devices and techniques.

181B. Introduction to Computer Vision
(4) WANG, TURK

Prerequisite: Upper-division standing.

Same course as ECE 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.

182. Multimedia Computing
(4) ALMEROTH

Prerequisites: Computer Science 176B.

Not open for credit to students who have completed ECE 160.

Introduction to multimedia and applications. Topics include streaming media, conferencing, webcasting, digital libraries, multimedia system architectures, standards (including JPEG and MPEG), and multimedia storage and retrieval. A key emphasis is on using the Internet for delivery of multimedia data.

185. Human-Computer Interaction
(4) HOLLERER

Prerequisite: open to computer science, computer engineering, and electrical engineering majors.

Recommended preparation: 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 enjoyable computer interfaces. This course teaches the theory, design guidelines, programming practices, and evaluation procedures behind effective human interaction with computers.

186. Theory of Computation
(4) IBARRA

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

Not open for credit to students who have completed Mathematics 150A.

Turing machines; computability and unsolvability; computational complexity; intractability and NP-completeness.

189A. Senior Computer Systems Project
(4) BULTAN

Prerequisite: senior standing in Computer Engineering, Electrical Engineering, or Computer Science; consent of instructor.

Not open for credit to students who have completed Computer Science 172.

Student groups design a significant computer-based project. Groups work independently with interaction among groups via interface specifications and informal meetings.

189B. Senior Computer Systems Project
(4) GONZALEZ

Prerequisite: CMPSC 172 or CMPSC 189A; Senior standing in computer engineering, computer science, or electrical engineering; consent of instructor.

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
(4) STAFF

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
(4) STAFF

Prerequisite: consent of instructor.

Students must have a minimum 3.0 GPA. May be repeated with consent of the department chair but only 4 units may be applied to the major.

Projects in computer science for advanced undergraduate students.

193. Internship in Industry
(1-4) STAFF

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 science electives. May be repeated with faculty/chair approval to a maximum of 4 units.

Special projects for selected students. Offered in conjunction with selected industrial and research firms under direct faculty supervision. Prior departmental approval required. Written proposal and final report required.

196. Undergraduate Research
(2-4) STAFF

Prerequisites: upper-division standing, 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. 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.

199. Independent Studies in Computer Science
(1-4) STAFF

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 combined.

Independent study in computer science for advanced students.

GRADUATE COURSES

209. Logic and Applications in Computer Science
(4) SU

Propositional logic, first order logic, completeness, compactness, incompleteness, undecidability; selected topics from finite model theory, theorem proving, logic programming, program verification, databases, computational complexity.

211A. Matrix Analysis and Computation
(4) STAFF

Prerequisite: consent of instructor.

Same course as ECE 210A, ME 210A, Mathematics 206A, Chemical Engineering 211A, and Geology 251A. Students should be proficient in basic numerical methods, linear algebra, mathematically rigorous proofs, and some programming language.

Graduate level-matrix theory with introduction to matrix computations. SVD's, pseudoinverses, variational characterization of eigenvalues, perturbation theory, direct and iterative methods for matrix computations.

211B. Numerical Simulation
(4) PETZOLD

Prerequisite: consent of instructor.

Same course as ECE 210B, ME 210B, Mathematics 206B, Chemical Engineering 211B, and Geology 251B. Students should be proficient in basic numerical methods, linear algebra, mathematically rigorous proofs, and some programming language.

Linear multistep methods and Runge-Kutta methods for ordinary differential equations: stability, order, and convergence. Stiffness. Differential algebraic equations. Numerical solution of boundary value problems.

211C. Numerical Solution of Partial Differential Equations—Finite Difference Methods
(4) STAFF

Prerequisite: consent of instructor.

Same course as ECE 210C, ME 210C, Mathematics 206C, Chemical Engineering 211C, and Geology 251C. Students should be proficient in basic numerical methods, linear algebra, mathematically rigorous proofs, and some programming language.

Finite difference methods for hyperbolic, parabolic and elliptic PDEs, with application to problems in science and engineering. Convergence, consistency, order and stability of finite difference methods. Dissipation and dispersion. Finite volume methods. Software design and adaptivity.

211D. Numerical Solution of Partial Differential Equations—Finite Element Methods
(4) STAFF

Prerequisite: consent of instructor.

Same course as ECE 210D, ME 210D, Mathematics 206D, Chemical Engineering 211D, and Geology 251D. Students should be proficient in basic numerical methods, linear algebra, mathematically rigorous proofs, and some programming language.

Weighted residual and finite element methods for the solution of hyperbolic, parabolic, and elliptical partial differential equations, with application to problems in science and engineering. Error estimates. Standard and discontinuous Galerkin methods.

216. Level Set Methods
(4) GIBOU

Prerequisite: Computer Science 211C, or Chemical Engineering 211C, or ECE 210C, or ME 210C.

Same course as Chemical Engineering 226, ECE 226, and ME 216.

Mathematical description of the level set method and design of the numerical methods used in its implementations (ENO-WENO, Godunov, Lax-Friedrich, etc.). Introduction to the Ghost Fluid Method. Applications in CFD, Materials Sciences, Computer Vision and Computer Graphics.

220. Theory of Computation and Complexity
(4) IBARRA

Prerequisite: Computer Science 186.

Topics include: models of computation; time and space complexity classes (e.g., P, NP, Co-NP, and PSPACE), efficient reducibilities, complete problems; lower bounds; the polynomial hierarchy.

225. Information Theory
(4) VAN DAM

Prerequisites: ECE 140 or PSTAT 120A-B.

Same course as ECE 205A.

Entropy, mutual information, and Shannon's coding theorems; lossless source coding, Huffman, Shannon-Fano-Elias, and arithmetic codes; Channel capacity; rate-distortion theory, and lossy source coding; source-channel coding; algorithmic complexity and information; applications of information theory in various fields.

230. Approximations, NP-Completeness and Algorithms
(4) GONZALEZ

Prerequisites: Computer Science 130A-B.

Epsilon approximations, PTAS and FPTAS. Techniques for the design of approximation algorithms. P, NP, NP-complete problems, polynomial transformations, Turing reductions, strong NP-completeness, NP-hardness and inapproximability results. Topics in algorithms include: amortized analysis, advanced graph algorithms and data structures.

231. Topics in Combinatorial Algorithms
(4) SURI

Prerequisite: Computer Science 130B.

Advanced topics in algorithm design, including network flows, matchings in graphs, linear and integer programming.

234. Randomized Algorithms
(4) EGECIOGLU

Prerequisite: Computer Science 186..

Randomized algorithms and applications: Las Vegas and Monte Carlo type algorithms, randomized algorithms for graph problems, matchings, data structures, problems from computational geometry, number theory and primality testing, distributed algorithms, hashing and fingerprinting, random generation, Markov chains and rapid mixing.

235. Computational Geometry
(4) SURI

Prerequisites: Computer Science 130A-B.

Algorithms and lower bound techniques in computational geometry; decision tree models of computation; geometric searching; point location and range search; convex hull and maxima of a point set; proximity algorithms; geometric intersections.

240A. Applied Parallel Computing
(4) GILBERT

Prerequisites: Computer Science 154 and 160.

Interdisciplinary introduction to applied parallel computing on modern supercomputers. Topics include applications-oriented architectural issues, MPI, parallel MATLAB, and parallel numerical algorithms. A course project emphasizes understanding the realities and myths of what is possible on the world's fastest machines.

240B. Parallel Computing and Program Parallelization
(4) YANG

Prerequisites: Computer Science 130A and 160.

Parallel programming; representation of parallelism, program dependence analysis, loop transformation; program and data partitioning, locality optimization; task scheduling and load balancing; parallelizing compilers and run-time support.

254. Advanced Computer Architecture
(4) SHERWOOD

Prerequisite: Computer Science 154 or ECE 154.

Advanced instruction set architectures, pipelining, dynamic scheduling, branch prediction, superscalar issue, out-of-order execution, memory-hierarchy design, advanced cache architectures, and prefetching. Several real designs are dissected and simulators are developed for performing quantitative evaluations of design decisions.

260. Advanced Topics in Translation
(4) STAFF

Prerequisites: Computer Science 160 and 162.

Theoretical aspects of translation. Topics include: data flow analysis; control flow analysis; interprocedural analysis; optimization; type systems.

263. Modern Programming Languages and Their Implementation
(4) KRINTZ

Prerequisites: Computer Science 154, 160, and 162.

Recommended preparation: Computer Science 260.

Topics central to modern programming languages and their implementation: garbage collection; memory system performance; characteristics and optimization of object-oriented languages; type systems and type inference; run-time compilation.

265. Advanced Topics in Machine Intelligence
(4) STAFF

Prerequisite: Computer Science 165A.

May be repeated for credit.

Topics covered include advanced programming techniques for representing and reasoning about complex objects and various applications of such techniques, including expert systems, natural language processors, image understanding systems, and machine learning.

266. Formal Specification and Verification
(4) KEMMERER

Prerequisites: Computer Science 130A-B; Computer Science 186.

Introduction to existing specification and verification systems, and the underlying theory and techniques of verifying the correctness of algorithms with respect to specifications. This subject can be considered as the combination of specification and verification techniques, programming language semantics, and formal logic.

267. Automated Verification
(4) BULTAN

Prerequisites: Computer Science 130A-B and 138.

Covers automated verification algorithms and tools. Topics include: temporal logics, fixpoint characterizations of temporal properties, model checking, symbolic verification, explicit-state verification, verification using automated theorem provers, automated abstraction.

270. Operating Systems
(4) WOLSKI

Prerequisite: Computer Science 170.

Develop an understanding of operating systems and operating systems research at both a conceptual level and from an engineering perspective. Fundamental design principles, culled primarily from the research literature, motivate an analysis of previous and current systems. This analysis is further validated through empirical investigation.

271. Advanced Topics in Distributed Systems
(4) EL ABBADI
Prerequisite: Computer Science 170.
Course covers the fundamental problems in distributed systems and the various tools used to solve them. Of primary interest is the issue of fault-tolerance. Topics include event ordering, clocks, global states, agreement, fault tolerance, and peer-to-peer systems.

272. Software Engineering
(4) BULTAN
Prerequisite: Computer Science 172.
Principles of software engineering disciplines emphasizing requirements analysis, specification design, coding, testing and correctness proofs, maintenance, and management. Students will use a number of software engineering tools.

273. Data and Knowledge Bases
(4) SU
Prerequisite: Computer Science 186.
The focus is on the study of relational and post-relational data models and their query languages of different styles (algebraic, calculus, and deductive): complexity, expressive power, optimization, and database design.

274. Advanced Topics in Database Systems
(4) AGRAWAL, EL ABBADI
Prerequisite: Computer Science 170.
Topics include: data models, semantics; data integrity; database design; serializability theory, concurrency control, recovery, distributed databases.

276. Advanced Topics in Networking
(4) BELDING, ZHAO
Prerequisite: Computer Science 176A or 176B.
Focuses on advanced topics in networking. Topics may include, but are not limited to: Internet analysis, routing techniques, multimedia, approaches for network performance enhancements, and communication over new technologies.

279. Advanced Topics in Security
(4) VIGNA
Prerequisite: Computer Science 177.
Security analysis of networked systems. Analysis of techniques for network scanning, spoofing, hijacking, and denial-of-service attacks. Vulnerability analysis of applications and web-based systems. Intrusion detection and prevention techniques.

280. Computer Graphics
(4) HOLLERER
Prerequisite: Computer Science 180.
Special topics in computer graphics including: curves and curved surfaces, visual perception of colors and color models; shading models; shadow generation; texture mapping; solid textures; stereographics; helmet-mounted display; graphics hardware/architecture; solid modeling; physically-based modeling; fractals and graphtals; volume rendering; scientific visualization.

281B. Advanced Topics in Computer Vision
(4) WANG, TURK
Same course as ECE 281B.
Advanced topics in computer vision: image sequence analysis, spatio-temporal filtering, camera calibration and hand-eye coordination, robot navigation, shape representation, physically-based modeling, regularization theory, multi-sensory fusion, biological models, expert vision systems, and other topics selected from recent research papers.

284. Mobile Computing
(4) BELDING
Prerequisite: Computer Science 176A or 176B.
Recommended preparation: Computer Science 276
Focuses on mobile computing. Topics may include, but are not limited to: mobile network characteristics, types of mobile networks, challenges and solutions in mobile computing, and power conservation techniques.

290AA-ZZ. Special Topics in Computer Science
(4) STAFF
Prerequisite: consent of instructor.
These courses provide for the study of topics of current interest in computer science. Special topics are coded as follows:
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

501. Techniques of Computer Science Teaching
(1) STAFF
This course is required for new teaching assistants and may be taken only once. No unit credit allowed toward advanced degree.
An initial 1-2 day workshop on teaching techniques followed by a weekly seminar. Course emphasizes teaching skills, practical experience, and communication skills.

502. Teaching of Computer Science
(1-4) STAFF
Prerequisite: Computer Science 501 (may be taken concurrently).
No unit credit allowed toward advanced degree.
Procedures and techniques for teaching computer science gained through actual teaching of lecture courses, leading discussion sections, and/or teaching laboratories. Meetings will be held as needed to discuss problems, methods and procedures.

592. Group Studies: Controls, Dynamical Systems, and Computation
(1) STAFF
Same course as Chemical Engineering 295, ECE 295, and ME 295.
A series of weekly lectures given by university staff and outside experts in the fields of control systems, dynamical systems, and computation.

593. Computer Science Graduate Tutorial
(1-12) STAFF
Prerequisite: consent of instructor or department chair.
Individual studies exploring topics in computer science with a faculty advisor.

594. Seminar in Computer Science
(1-5) STAFF
Prerequisite: consent of instructor and department.
A seminar course offered on an irregular basis. Provides an in-depth discussion of advanced topics of general interest and broadens the scope of knowledge in computer science.

595AA-ZZ. Group Studies in Computer Science
(1-2) STAFF
Prerequisite: consent of instructor.
May be repeated for credit provided letter designations are different.
Special seminars focusing on topics of interest to faculty and graduate students. These seminars provide critical review of research in various areas of 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
J. General
K. Computer Systems Modeling and Analysis
N. General

596. Directed Research
(2-12) STAFF
Research, either experimental or theoretical, may be undertaken by properly qualified graduate students under the direction of a faculty member.

597. Individual Studies for M.S. Comprehensive Examinations and Ph.D. Examinations
(1-12) STAFF
No unit credit allowed toward advanced degree. Enrollment limited to 24 units per examination. Maximum of 12 units per quarter. Instructor is normally student's major professor or chair of doctoral committee. S/U grading.
Individual studies for M.S. comprehensive examination and Ph.D. examinations.

598. Master's Thesis Research and Preparation
(1-12) STAFF
Prerequisite: consent of graduate advisor.
For research underlying the thesis and writing of the thesis.

599. Ph.D. Dissertation Research and Preparation
(1-12) STAFF
Prerequisite: consent of chair of student's doctoral committee.
Research and preparation of dissertation.

Electrical and Computer Engineering

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Chair: Jerry Gibson
Vice Chair: Joao Hespanha

Faculty

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)

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, 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)

Elliott Brown, Ph.D., California Institute of Technology, Professor (RF system modeling and design; solid state and biomedical ultrasonics; thermal management of solid state power devices)

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)

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

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

Larry A. Coldren, Ph.D., Stanford University, Kavli 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

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, Professor (metalorganic vapor phase epitaxy, optoelectronic materials, compound semiconductors, indium phosphide and gallium nitride, photonic devices) *1

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

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

Joao Hespanha, Ph.D., Yale University, Professor (hybrid and switched systems, supervisory control, control of computer networks, probabilistic games, the use of vision in feedback control)

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

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

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

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

Michael Liebling, Ph.D., École Polytechnique Fédérale de Lausanne, Assistant Professor (image processing, optical microscopy, In Vivo biological imaging)

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

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

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

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

Umesh Mishra, Ph.D., Cornell University, 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)

Louise E. Moser, Ph.D., University of Wisconsin, Professor (distributed systems, computer networks, software engineering, fault-tolerance, formal specification and verification, performance evaluation)

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

Pierre M. Petroff, Ph.D., UC Berkeley, Professor (self assembling nanostructures in semiconductors and ferromagnetic materials, spectroscopy of nanostructures, nanostructure devices, semiconductor device reliability) *1

Lawrence Rabiner, Ph.D., Massachusetts Institute of Technology, Professor (digital signal processing: intelligent human-machine interaction, digital signal processing, speech processing and recognition; telecommunications)

Volkan Rodoplu, Ph.D., Stanford University, Associate Professor (wireless networks, energy-efficient and device-adaptive communications)

Mark J.W. Rodwell, Ph.D., Stanford University, Professor, Director of Compound Semiconductor Research Laboratories, Director of National Nanofabrication Users Network (heterojunction bipolar transistors, high frequency integrated circuit design, electronics beyond 100 GHz)

Kenneth Rose, Ph.D., California Institute of Technology, Professor, Co-Director of Center for Information Processing Research (information theory, source and channel coding, image coding, communications, pattern recognition)

John J. Shynk, Ph.D., Stanford University, Professor (adaptive filtering, array processing, wireless communications, blind equalization, neural networks)

Roy Smith, Ph.D., California Institute of Technology, Professor (robust control with an emphasis on the modeling, identification, and control of uncertain systems, applications and experimental work including process control, flexible structures, automotive systems, semiconductor manufacturing, levitated magnetic bearings and dynamic aeromaneuvering of interplanetary spacecraft)

Andrew Teel, Ph.D., UC Berkeley, 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, Assistant 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, Austin, Associate Professor (design verification, testing, computer-aided design of microprocessors)

Pochi Yeh, Ph.D., California Institute of Technology, Professor (phase conjugation, nonlinear optics, dynamic holography, optical computing, optical interconnection, neural networks, and image processing)

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

Patrick Yue, Ph.D., Stanford University, Associate Professor (high-speed CMOS IC design, cell-based RF CAD methodology and integrated biomedical sensors)

Emeriti Faculty

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

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

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

Petar V. Kokotovic, Ph.D., USSR Academy of Sciences, Professor, 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)

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

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)

James L. Merz, Ph.D., Harvard University, Professor Emeritus (optical properties of semiconductors, including guided-wave and integrated optical devices, semiconductor lasers, optoelectronic devices, native defects in semiconductors, low-dimensional quantum structures) *1

Sanjit K. Mitra, Ph.D., UC Berkeley, Professor (digital signal and image processing, computer-aided design and optimization)

Venkatesh Narayanamurti, Ph.D.,

Cornell University, Professor Emeritus (transport, semiconductor heterostructures, nanostructures, scanning tunneling microscopy and ballistic electron emission microscopy, phonon physics)

Philip F. Ordung, D. Eng., Yale University, Professor Emeritus (general device physics, solar cells, charge-coupled devices)

Ian B. Rhodes, Ph.D., Stanford University, Professor (mathematical system theory and its applications with emphasis on stochastic control, communication, and optimization problems, especially those involving decentralized information structures or parallel computational structures)

John G. Skalnik, D. Eng., Yale University, Professor Emeritus (solar cells, general device technology, effects of non-ideal structures)

Glen Wade, Ph.D., Stanford University, Professor Emeritus (optical, microwave, and acoustical systems theory and experiments, with emphasis on acoustic imaging; computer processing; enhancement of images; computer image reconstruction)

Roger C. Wood, Ph.D., UC Los Angeles, Professor Emeritus (computer system modeling, design, and analysis, computer architecture, and instructional use of computers) *2

*1 Joint appointment with the Department of Materials.
*2 Joint appointment with the Department of Computer Science.

Affiliated Faculty

David Awschalom, Ph.D. (Physics)

Elizabeth Belding, Ph.D. (Computer Science)

Francesco Bullo, Ph.D. (Mechanical Engineering)

Francis Doyle, Ph.D., (Chemical Engineering)

Oscar Ibarrra, Ph.D., (Computer Science)

Mustafa Khammash, Ph.D. (Mechanical Engineering)

Chandra Krintz, Ph.D. (Computer Science)

Eric McFarland, Ph.D., (Chemical Engineering)

Shuji Nakamura, Ph.D. (Materials)

Bradley E. Paden, Ph.D. (Mechanical Engineering)

Tim Sherwood, Ph.D. (Computer Science)

Electrical and Computer Engineering is a broad field encompassing many diverse areas such as computers and digital systems, control, communications, computer engineering, electronics, signal processing, electromagnetics, electro-optics, physics and fabrication of electronic and photonic devices. As in most areas of engineering, knowledge of mathematics and the natural sciences is combined with engineering fundamentals and applied to the theory, design, analysis, and implementation of devices and systems for the benefit of society.

The Department of Electrical and Computer Engineering offers programs leading to the degrees of bachelor of science in electrical engineering or bachelor of science in computer engineering. (Please see the "Computer Engineering" section for further information.) The undergraduate curriculum in electrical engineering is designed to provide students with a solid background in mathematics, physical sciences, and traditional electrical engineering topics as presented above. A wide range of program options, including computer engineering; microwaves; communications, control, and signal processing; and semiconductor devices and applications, is offered. The department's Electrical Engineering undergraduate program is accredited by the Engineering Accreditation Commission of ABET, 111 Market Place, Suite 1050, Baltimore, MD 21202-4012 – telephone: (410) 347-7700. It is one of the degrees recognized in all fifty states as leading to eligibility for registration as a professional engineer.

Graduate studies leading to the M.S. and Ph.D. degrees in Electrical and Computer Engineering are offered in three major areas of specialization: computer engineering; communications, control, and signal processing; and electronics and photonics.

The undergraduate major in Electrical Engineering prepares students for a wide range of positions in business, government, and private industrial research, development, and manufacturing organizations. The graduate programs offer educational opportunities at an advanced level, leading at the M.S. level to increased career opportunities in the foregoing positions, and at the Ph.D. level to careers in research and teaching and positions of professional leadership.

Students who complete a major in electrical engineering may be eligible to pursue a California teaching credential. Interested students should consult the credential advisor in the Graduate School of Education.

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.

Program Outcomes

The EE program expects our students upon graduation to have:

1. Acquired strong basic knowledge and skills in those fundamental areas of mathematics, science, and electrical engineering that are required to support specialized professional training at the advanced level and to provide necessary breadth to the student's overall program of studies. This provides the basis for lifelong learning.
2. Experienced in-depth training in state-of-the-art specialty areas in electrical engineering. This is implemented through our senior electives. Students are required to take two sequences of at least two courses each at the senior level.
3. Benefited from imaginative and highly supportive laboratory experiences where appropriate throughout the program. The laboratory experience will be closely integrated with coursework and will make use of up-to-date instrumentation and computing facilities. Students should experience both hardware-oriented and simulation-oriented exercises.
4. Experienced design-oriented challenges that exercise and integrate skills and knowledge acquired in several courses. These may include design of components or subsystems with performance specifications. Graduates should be able to demonstrate an ability to design and conduct experiments as well as analyze the results.
5. Learned to function well in teams. Also, students must develop communication skills, written and oral, both through team and classroom experiences. Skills including written reports, webpage preparation, and public presentations are required.
6. Completed a well-rounded and balanced education through required studies in selected areas of fine arts, humanities, and social sciences. This provides for the ability to understand the impact of engineering solutions in a global and societal context. A course in engineering ethics is also required of all undergraduates.

Undergraduate Program

Note: Schedules should be planned to meet both General Education and major requirements. Detailed descriptions of these requirements are presented in the College of Engineering Announcement and General Education booklet.

A minimum of 193 units is required for graduation.

Bachelor of Science—Electrical Engineering

Preparation for the major

All undergraduate majors in the department are required to meet a set of minimum unit and grade-point requirements and a set of General Education requirements which are common to all undergraduate majors in the College of Engineering. In addition, required preparation for the major consists of the following lower-division courses (or their equivalents if taken elsewhere): Engineering 3; Electrical and Computer Engineering 2A-B-C and 15A; Chemistry 1A-B or 2A-B, 1AL-BL or 2AC-BC; Mathematics 3A-B-C and 5A-B-C; Physics 1, 2, 3, 4, 5, 3L, 4L, 5L; and Computer Science 16 and 24. Qualified students may substitute Physics 21-25 for Physics 1-5 after obtaining permission from the Physics Department.

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.

Upper-division major

The upper-division requirements consist of a set of required courses and a minimum of 32 units (8 classes) of additional departmental elective courses selected from a wide variety of specialized courses. All departmental elective programs must contain at least two sequences, each consisting of two or more related courses. Required upper-division courses for the major are: Electrical and Computer Engineering 130A-B, 132, 134, 137A-B, 139, 152A; and Engineering 101.

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. 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-C and Mathematics 5A and 5B 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 13.

Electrical and Computer Engineering Courses

Many of the ECE courses are restricted to ECE majors only. Please check the quarterly Schedule of Classes. Instructor and quarter offered are subject to change.

LOWER DIVISION

1. Ten Puzzling Problems in Computer Engineering
(1) PARHAMI
Prerequisite: open to pre-computer engineering only. Seminar, 1 hour.

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.

2A. Circuits, Devices, and Systems
(5) YORK
Prerequisites: Mathematics 3A-B-C with a minimum grade of C; and, Mathematics 5A with a minimum grade of C (may be taken concurrently); Physics 3 or 23 (may be taken concurrently); open to electrical engineering, computer engineering, and pre-computer engineering majors only. Lecture, 3 hours; laboratory, 4 hours.

Introduction to basic circuit analysis. KCL, KVL, nodal analysis, superposition, independent and dependent sources; diodes and I-V characteristics; basic op-amp circuits; first-order transient analysis; AC analysis and phasors. Introduction to the use of test instruments.

2B. Circuits, Devices, and Systems
(5) YORK
Prerequisites: ECE 2A with a grade of C- or better; open to electrical engineering, computer engineering, and pre-computer engineering majors only. Lecture, 3 hours; laboratory, 4 hours.

Second order circuits. Laplace transform and solution of steady state and transient circuit problems in the s-domain; Bode plots; Fourier series and transforms; filters. Transistor as a switch; load lines; simple logic gates; latches and flip-flops.

2C. Circuits, Devices, and Systems
(5) YORK
Prerequisites: ECE 2B with a grade of C- or better (may be taken concurrently); open to electrical engineering, computer engineering, and pre-computer engineering majors only. Lecture, 3 hours; laboratory, 4 hours.

Two-port network parameters; small-signal models of nonlinear devices; transistor amplifier circuits; frequency response of amplifiers; non-ideal op-amps; modulation, bandwidth, signals; Fourier analysis.

4. Design Project for Freshmen
(4) STAFF
Prerequisites: Mathematics 3A-B-C and Physics 1 with minimum grades of C; Engineering 3 with a minimum grade of C-. Lecture, 3 hours; laboratory, 3 hours.

This first course on design gives an intuitive introduction to engineering design. Learn how to take an idea of a system and convert it to a working model. Use hardware and software for building a system.

15A. Fundamentals of Logic Design
(3) MAREK-SADOWSKA
Prerequisites: ECE 2A with a minimum grade of C-; open to electrical engineering, computer engineering, and pre-computer engineering majors only.

Not open for credit to students who have completed ECE 15. Lecture, 3 hours; discussion, 1 hour.

Boolean algebra, logic of propositions, minterm and maxterm expansions, Karnaugh maps, Quine-McCluskey methods, melti-level circuits, combinational circuit design and simulation, multiplexers, decoders, programmable logic devices.

15B. Computer Organization
(3) STAFF
Prerequisites: ECE 15A with a minimum grade of C-; open to electrical engineering, computer engineering, and pre-computer engineering majors only.

Not open for credit to students who have completed Computer Science 30 or ECE 15. Lecture, 3 hours; discussion, 1 hour.

Basic memory and processor organization, instruction set architecture, assembly language programming, number systems, arithmetic, data transfer and control flow instructions, procedures, memory management, program execution.

94AA-ZZ. Group Studies in Electrical and Computer Engineering
(1-4) STAFF
Prerequisite: consent of instructor.

Group studies intended for small number of advanced students who share an interest in a topic not included in the regular departmental curriculum.

UPPER DIVISION

121A-B. The Practice of Science
(3-4) HU, AWSCHALOM
Prerequisites: consent of instructor (for 121A): ECE 121A or Physics 121A; consent of instructor (for 121B).

Same course as Physics 121A-B. Lecture, 3 hours (for 121A): Lecture, 4 hours (for 121B).

Provides experience in pursuing careers within science and engineering through discussions with researchers, lectures on ethics, funding, intellectual property, and commercial innovation. Students prepare a focused research proposal that is pursued in the second quarter of the course.

124A. VLSI Principles
(4) BANERJEE
Prerequisites: ECE 132 (may be taken concurrently) and ECE 152A with a minimum grade of C- in both. Lecture, 3 hours; laboratory, 3 hours.

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 characterization: delay, noise margins, and power dissipation; combinational and sequential circuits; arithmetic operations and memories.

124B. Integrated Circuit Design and Fabrication
(4) BOWERS
Prerequisite: ECE 132 with a minimum grade of C-. Lecture, 4 hours; laboratory, 3 hours.

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.

124C. Integrated Circuit Design and Fabrication
(4) BOWERS
Prerequisites: ECE 124B and ECE 137A with a minimum grade of C- in all. Lecture, 4 hours; laboratory, 3 hours.

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. Circuit and discrete device electrical performance are analyzed.

124D. VLSI Architecture and Design
(4) BREWER
Prerequisite: ECE 124A with a minimum grade of C-.

Lecture, 3 hours; laboratory, 2 hours.

Practical issues in VLSI circuit design, pad/pin limitations, clocking and interfacing standards, electrical 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.

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, nanoscale issues including variability, thermal management, 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) MADHOW
Prerequisites: Mathematics 5A and ECE 2B with a minimum grade of C- in both; open to EE and computer engineering majors only. Lecture, 3 hours; discussion, 2 hours.

Analysis of continuous time linear systems in the time and frequency domains. Superposition and convolution. Bilateral and unilateral Laplace transforms. 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 and aliasing.

130C. Signal Analysis and Processing
(4) CHANDRASEKARAN
Prerequisites: ECE 130A-B with a minimum grade of C- in both. Lecture, 3 hours; discussion, 2 hours.

Basic techniques for the analysis of linear models in electrical engineering: Gaussian elimination, vector spaces and linear equations, orthogonality, determinants, eigenvalues and eigenvectors, systems of linear differential equations, positive definite matrices, singular value decomposition.

132. Introduction to Solid State Electronic Devices
(4) MISHRA
Prerequisites: Physics 4 or 24 with a minimum grade of C-; Mathematics 5A with a minimum grade of C; and ECE 2A-B (may be taken concurrently) with a minimum grade of C- in both; 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 properties of electrons and holes; P-N junction diodes; I-V, C-V, and switching properties of P-N junctions; introduction of bipolar transitors, MOSFET's and JFET's.

134. Introduction to Fields and Waves
(4) DAGLI, YORK
Prerequisites: Physics 3 or 23 with a minimum grade of C-; and Mathematics 5A-B with a minimum grade of C; and Mathematics 5C 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. Wave on transmission-lines, elements of electrostatics and magnetostatics and appications, 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 2A-B-C, 130A, and 132 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 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) ILTIS
Prerequisite: Open to Electrical Engineering, Computer Engineering and pre-Computer Engineering majors only. Lecture, 3 hours; discussion, 2 hours.

Fundamentals of probability, conditional probability, Bayes rule, random variables, functions of random variables, expectation and high-order moments, Markov chains, hypothesis testing.

140. Random Processes for Engineering
(4) ILTIS
Prerequisites: ECE 130A-B and 139 each with a minimum grade of C-; open to EE majors only. Lecture, 3 hours; discussion, 2 hours.

Random processes, characteristic functions, central limit theorem, spectral analysis, linear systems with random inputs, representation of bandlimited processes, Poisson process, simple queueing systems.

141A. Introduction To Nanoelectro-mechanical and Microelectromechanical Systems(NEMS/MEMS)
(3) PENNATUR, TURNER
Prerequisites: ME 16 & 17, ME 152A, ME 151A (may be concurrent); or, ECE 130A and 137A with a minimum grade of C- in both.

Same course as ME 141A. Lecture, 3 hours.

Introduction to nano- and microtechnology. Scaling laws and nanoscale physics are stressed. Individual subjects at the nanoscale including materials, mechanics, photonics, electronics, and fluidics will be described, with an emphasis on differences of behavior at the nanoscale and real-world examples.

141B. Semiconductor Processing and Device Characterization with Laboratory
(4) PENNATUR
Prerequisites: ME 141A or ECE 141A; and, Chemistry 1B-BL.

Same course as ME 141B. Lecture, 2 hours; laboratory, 6 hours.

Lectures and laboratory on semiconductor processing for MEMS. Description and analysis for key semiconductors and equipment used for MEMS. Design and fabrication of MEMS capacitor-actuator and accelerometers; includes a description of MEMS characterization tools.

141C. Introduction to Microfluidics and BioMEMS
(3) MEINHART
Prerequisite: ME 141A or ECE 141A; open to ME and EE majors only.

Same course as ME 141C. Lecture, 3 hours.

Introduces physical phenomena associated with microsale/nanoscale fluid mechanics, microfluids, and bioMEMS. Analytical methods and numerical simulation tools are used for analysis of microfluids.

144. Electromagnetic Fields and Waves
(4) YORK
Prerequisite: ECE 134 with a minimum grade of C-. Lecture, 3 hours; laboratory, 3 hours.

Waves on transmission lines, Maxwell's equations, skin effect, propagation and reflection of electromagnetic waves, microwave integrated circuit principles, metal and dielectric waveguides, resonant cavities, antennas. Microwave and optical device examples and experience with modern microwave and CAD software.

145A. Communication Electronics
(5) LONG
Prerequisites: ECE 137A-B with a minimum grade of C- in both. Lecture, 3 hours; laboratory, 6 hours.

Analog communication circuits 1 MHz to 1GHz with emphasis on receivers. S-parameter design techniques, nonideal components, distortion, amplifier design and characterization, system level analysis.

145B. Communication Electronics
(5) LONG
Prerequisite: ECE 145A with a minimum grade of C-; EE majors only. Lecture, 3 hours; laboratory, 6 hours.

Analog communication circuits 1 MHz to 1GHz with emphasis on receivers. Design and evaluation of RF components: mixers, oscillators, PLL, IF amplifier, FM demodulator, frequency synthesis.

145C. High Speed Bipolar Mixed Signal and Communication IC Design
(4) RODWELL
Prerequisites: ECE 137A-B with a minimum grade of C- in both. Lecture, 4 hours.

Transistor and passive component models. Broadband amplifiers. Fast digital IC design. Circuit noise, digital communication receiver sensitivity. Latched comparator design. Nyquist and oversampled analog-digital and digital-analog converters. Direct digital frequency synthesis. Fiber optic and microwave digital transceivers.

146A. Analog Communication Theory and Techniques
(5) ILTIS
Prerequisites: ECE 130A-B and 140 with a minimum grade of C- in all; open to EE majors only. Lecture, 3 hours; laboratory, 6 hours.

Modulation theory, AM, FM, PM, and analog pulse modulation and demodulation techniques. System noise and performance calculations.

146B. Digital Communication Theory and Techniques
(5) SHYNK
Prerequisites: ECE 130A-B, 140 and 146A with minimum grades of C-; open to EE majors only. Lecture, 3 hours; laboratory, 6 hours.

Elements of source coding: quantization, pulse code modulation, delta modulation. Introduction to digital modulation over baseband and passband channels: linear modulation, Nyquist criterion for intersymbol interference avoidance, orthogonal modulation. Optimal reception of signals in Additive White Gaussian Noise: detection theory basics, signal space concepts, geometry of maximum likelihood receivers. Performance analysis of optimal receivers: error probability as a function of Eb/N0, union bound, nearest neighbors approximation. Link design: power-bandwidth tradeoffs, link budget analysis.

147A. Feedback Control Systems - Theory and Design
(5) TEEL, SMITH
Prerequisites: ECE 130A-B-C 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) SMITH, TEEL
Prerequisite: ECE 147A with a minimum grade of C-; open to EE and computer engineering majors only. Lecture, 3 hours; laboratory, 6 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) HESPANHA
Prerequisite: 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

Prerequisites: ECE 130A-B with a minimum grade of C- in both. Lecture, 3 hours; discussion, 2 hours.

A sequence of engineering applications of signal analysis and processing techniques; in communications, image processing, analog and digital filer design, signal detection and parameter estimation, holography and tomography, Fourier optics, and microwave and acoustic sensing.

149. Active and Passive Network Synthesis
(4) ILTIS

Prerequisite: Upper-division standing; open to EE majors only.

Designed for juniors to take right after ECE 130AB.

Combines the areas of electronics and network theory in the subject of passive and active network design. Topics include passive synthesis, optimization techniques, approximations to ideal filters, distributed networks, sensitivity and the modern design techniques, and applications of active filters.

151. Distributed Systems
(4) MELLIAR-SMITH

Prerequisite: Computer Science 170 with a minimum grade of C-.

Not open for credit to students who have completed Computer Science 171. Lecture, 3 hours; discussion, 1 hour.

Distributed systems architecture, distributed programming techniques, message passing, remote procedure calls, group communication and membership, naming, asynchrony, causality, consistency, fault-tolerance and recovery, resource management, scheduling, monitoring, testing and debugging.

152A. Digital Design Principles
(5) RODOPLU

Prerequisites: ECE 15 or 15A or Computer Science 30 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.

Design of synchronous digital systems: timing diagrams, propagation delay, latches and flip-flops, shift registers and counters, Mealy/Moore finite state machines, Verilog, 2-phase clocking, timing analysis, CMOS implementation, S-RAM, RAM-based designs, ASM charts, state minimization.

152B. Digital Design Methodologies
(5) CHENG

Prerequisites: ECE 152A with a minimum grade of C-; open to EE, computer engineering, and computer science majors only. Lecture, 3 hours; discussion, 6 hours.

Design methodologies of digital systems, the register and processor levels. Design of functional subsystems, including arithmetic processors, hardwired and microprogrammed control units, memory systems, and bussing systems. System organization including communication, input/output systems, and multiple CPU systems.

153A. Hardware/Software Interface
(4) STAFF

Prerequisite: Computer Science 130A with a minimum grade of C-.

Same course as Computer Science 153A.

The study of the structures employed at the interface of hardware and software in modern computing systems. Instruction set architecture (ISA) design trade-offs, operating system and hardware support for input/output devices (memory-mapping, interrupts, device drivers). Operating system and real-time system scheduling of tasks. Low level software and program support infrastructures (virtualization, compilation, optimization, emulation/simulation, debugging).

153B. Sensor and Peripheral Interface Design
(4) BUTNER

Prerequisites: ECE 152B and 153A with a minimum grade of C- in both. Lecture, 3 hours; laboratory, 3 hours.

Hardware description languages; field-programmable 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.

154. Introduction to Computer Architecture
(4) PARHAMI

Prerequisite: ECE 152A with a minimum grade of C-; open to EE, computer engineering, and computer science majors only.

Not open for credit to students who have completed Computer Science 154. Lecture, 3 hours; discussion, 1 hour.

The computer design space. Methods of performance evaluation. Machine instructions and assembly language. Variations in instruction set architecture. Design of arithmetic/logic units. Data path and control unit synthesis. Pipelining and multiple instruction issue. Hierarchical memory systems. Input/output and interfacing. High-performance systems, including multiprocessors and multicomputers.

155A. Introduction to Computer Networks
(4) MOSER

Prerequisite: ECE 154 with a minimum grade of C-; and, Computer Science 12 or 60 with a minimum grade of C-.

Not open for credit to students who have completed Computer Science 176 or 176A, or ECE 155. Lecture, 3 hours; discussion, 1 hour.

Topics in this course include network architectures, protocols, wired and wireless networks, transmission media, multiplexing, switching, framing, error detection and correction, flow control, routing, congestion control, TCP/IP, DNS, email, World Wide Web, network security, socket programming in C/C++.

155B. Network Computing
(4) MOSER

Prerequisites: ECE 155A with a minimum grade of C-; and, Computer Science 5JA or 10 or 11JA with a minimum grade of C-.

Not open for credit to students who have completed Computer Science 176B or ECE 194W. Lecture, 3 hours; discussion, 1 hour.

Topics in this course include client/server computing, threads, Java applets, Java sockets, Java RMI, Java servlets, Java Server Pages, Java Database Connectivity, Enterprise Java Beans, Hypertext Markup Language, extensible Markup Language, Web Services, programming networked applications in Java.

156A. Digital Design with VHDL and Synthesis
(4) WANG

Prerequisite: ECE 152A with a minimum grade of C-. Lecture, 3 hours; laboratory, 3 hours.

Introduction to VHDL basic elements. VHDL simulation concepts. VHDL concurrent statements with examples and applications. VHDL subprograms, packages, libraries and design units. Writing VHDL for synthesis. Writing VHDL for finite state machines. Design case study.

156B. Computer-Aided Design of VLSI Circuits
(4) WANG

Prerequisite: ECE 156A with a minimum grade of C-. Lecture, 3 hours; laboratory, 3 hours.

Introduction to computer-aided simulation and synthesis tools for VLSI. VLSI system design flow, role of CAD tools, layout synthesis, circuit simulation, logic simulation, logic synthesis, behavior synthesis and test synthesis.

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.

Discrete signals and systems, convolution, z-transforms, discrete Fourier transforms, digital filters.

160. Multimedia Systems
(4) MELLIAR-SMITH

Prerequisites: upper-division standing; open to EE, computer engineering, computer science, and creative studies majors only. Lecture, 3 hours; laboratory, 3 hours.

Introduction to multimedia and applications, including WWW, image/video databases and video streaming. Covers media content analysis, media data organization and indexing (image/video databases), and media data distribution and interaction (video-on-demand and interactive TV).

162A. The Quantum Description of Electronic Materials
(4) BOWERS

Prerequisites: ECE 130A-B and 134 with a minimum grade of C- in all; open to EE and materials majors only.

Same course as Materials 162A. Lecture, 4 hours.

Electrons as particles and waves, Schrodinger's equation and illustrative solutions. Tunnelling. Atomic structure, the exclusion principle and the periodic table. Bonds. Free electrons in metals, periodic potentials and energy bands.

162B. Fundamentals of the Solid State
(4) COLDREN

Prerequisite: ECE 162A with a minimum grade of C-; open to EE and materials majors 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) COLDREN

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, photo diodes, modulators. Photoemission. Integrated circuits.

178. Introduction to Digital Image and Video Processing
(4) MANJUNATH

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 coding standards.

181A. Introduction to Robotics: Robot Mechanics
(4) PADEN

Same course as ME 170A.

Recommended preparation: ME 16. Lecture, 3 hours; laboratory, 3 hours.

Overview of robot kinematics and dynamics. Structure and operation of industrial robots. Robot performance: work space, velocity, precision, payload. Comparative discussion of robot mechanical designs. Actuators. Robot coordinate systems. Kinematics of position. Dynamics of manipulators.
(S; may not be offered every year)

181B. Introduction to Computer Vision
(4) MANJUNATH

Prerequisite: Upper-division standing.

Same course as Computer Science 181B.

Overview of computer vision problems and techniques 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.

181C. Introduction to Robotics: Robot Control
(4) PADEN

Prerequisite: ECE 2A-B-C with a minimum grade *of C-; or ME 104.*

Same course as ME 170C. Lecture, 2 hours; laboratory, 4 hours.

Overview of robot control technology from open-loop manipulators and sensing systems, to single-joint servovalves and servomotors, to integrated adaptive force and position control using feedback from machine vision and touch sensing systems. Design emphasis on accurate tracking accomplished with minimal algorithm complexity. (F; may not be offered every year)

183. Nonlinear Phenomena

(4) TEEL

Prerequisites: Physics 105A or ME 163 or upper-division standing in EE.

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

(4) STAFF

Prerequisites: completion of at least 4 upper-division EE courses with a GPA of 3.0 or higher; open to EE and computer engineering, majors only; consent of instructor.

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

(4) STAFF

Prerequisites: ECE 188A with a minimum grade of C-; electrical engineering and computer engineering majors only.

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-B. Senior Computer Systems Project

(4-4) BUTNER

Prerequisite: consent of instructor; senior standing in computer engineering, computer science, or EE.

Not open for credit to students who have completed Computer Science 189.

Student groups design a significant computer-based project. Groups work independently with interaction among groups via interface specifications and informal meetings.

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

Prerequisite: consent of instructor. Variable hours.

Group studies intended for small number of advanced students who share an interest in a topic not included in the regular departmental curriculum. Topics covered include (check with department for quarters offered):

A. Circuits
AA. Micro-Electro-Mechanical Systems
B. Systems Theory
BB. Computer Engineering
C. Communication Systems
D. Control Systems
E. Signal Processing
F. Solid State
G. Fields and Waves
H. Quantum Electronics
I. Microwave Electronics
J. Switching Theory
K. Digital Systems Design
L. Computer Architecture
M. Computer Graphics
N. Pattern Recognition
O. Microprocessors and Microprocessor-based Systems
P. Simulation
Q. Imaging Systems and Image Processing
R. General
S. Speech
T. Robot Control
U. Optoelectronics
V. Scientific Computation
W. Computer Network
X. Distributed Computation
Y. Numerical Differential Equations
Z. Nanotechnology

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

201A. Electromagnetic Theory I

(4) DAGLI

Prerequisite: ECE 144. Lecture, 4 hours.

Basic concepts in electromagnetic theory, energy power, plane waves, guided waves, dielectric metallic waveguides, radiation, uniqueness, image theory, reciprocity, duality, equivalence principle, induction theorem.

205A. Information Theory

(4) ROSE

Prerequisites: ECE 140 or equivalent, or PSTAT 120A-B.

Same course as Computer Science 225. Lecture, 4 hours.

Entropy, mutual information, and Shannon's coding theorems; lossless source coding, Huffman, Shannon-Fano-Elias, and arithmetic codes; channel capacity; rate-distortion theory, and lossy source coding; source-channel coding; algorithmic complexity and information; applications of information theory in various fields.

207. Research Projects or Independent Studies

(1-6) STAFF

Prerequisite: consent of instructor. Variable hours.

Graduate research projects or independent studies to be arranged between students and staff members. See M.S. degree requirements, plans 1 and 2, regarding number of units which may be used for M.S. degree.

210A. Matrix Analysis and Computation

(4) CHANDRASEKARAN

Prerequisite: consent of instructor.

Same course as Computer Science 211A, Mathematics 206A, ME 210A, Chemical Engineering 211A, and Geology 251A. Students should be proficient in basic numerical methods, linear algebra, mathematically rigorous proofs, and some programming language. Lecture, 4 hours.

Graduate level-matrix theory with introduction to matrix computations. SVD's, pseudoinverses, variational characterization of eigen values, perturbation theory, direct and iterative methods for matrix computations.

210B. Numerical Simulation

(4) PETZOLD

Prerequisite: consent of instructor.

Same course as Computer Science 211B, Mathematics 206B, ME 210B, Chemical Engineering 211B and Geology 251B. Students should be proficient in basic numerical methods, linear algebra, mathematically rigorous proofs, and some programming language. Lecture, 4 hours.

Linear multistep methods and Runge-Kutta methods for ordinary differential equations: stability, order and convergence. Stiffness. Differential algebraic equations. Numerical solution of boundary value problems.

210C. Numerical Solution of Partial Differential Equations—Finite Difference Methods

(4) STAFF

Prerequisite: consent of instructor.

Same course as Computer Science 211C, Mathematics 206C, ME 210C, Chemical Engineering 211C and Geology 251C. Students should be proficient in basic numerical methods, linear algebra, mathematically rigorous proofs, and some programming language. Lecture, 4 hours.

Finite difference methods for hyperbolic, parabolic and elliptic PDEs, with application to problems in science and engineering. Convergence, consistency, order and stability of finite difference methods. Dissipation and dispersion. Finite volume methods. Software design and adaptivity.

210D. Numerical Solution of Partial Differential Equations—Finite Element Methods

(4) STAFF

Prerequisite: consent of instructor.

Same course as Computer Science 211D, Mathematics 206D, ME 210D, Chemical Engineering 211D and Geology 251D. Students should be proficient in basic numerical methods, linear algebra, mathematically rigorous proofs, and some programming language. Lecture, 4 hours.

Weighted residual and finite element methods for the solution of hyperbolic, parabolic and elliptical partial differential equations, with application to problems in science and engineering. Error estimates. Standard and discontinuous Galerkin methods.

211A. Engineering Quantum Mechanics I

(4) STAFF

Prerequisites: ECE 162A-B. Students must have some knowledge of linear algebra.

Same course as Materials 211A. Lecture, 4 hours.

Wave-particle duality; bound states; uncertainty relations; expectation values and operators; variational principle; eigenfunction expansions; perturbation theory I. Treatment matches needs and background of ECE and Materials students emphasizing solid state or quantum electronics.

211B. Engineering Quantum Mechanics II

(4) STAFF

Prerequisites: ECE 211A or Materials 211A, or ECE 215A or Materials 206A.

Same course as Materials 211B. Lecture, 4 hours.

Continuation of ECE 211A; symmetry and degeneracy; electrons in crystals, angular momentum; perturbation theory II; transition probabilities; quantized fields and radiative transitions; magnetic fields; electron spin; indistinguishable particles.

215A. Fundamentals of Electronic Solids I

(4) BROWN

Prerequisite: ECE 162A or 162B.

Same course as Materials 206A. Lecture, 4 hours.

Introduction into the physics of semiconductors for beginning engineering graduate students. Crystal structure. Reciprocal lattice and crystal diffraction. Electrons in periodic structures. Energy and bands. Semiconductor electrons and probes, Fermi statistics.

215B. Fundamentals of Electronic Solids II
(4) BROWN

Prerequisite: ECE 162A or 162B.

Same course as Materials 206B. Lecture, 4 hours.

Phonons, electron scattering, electronic transport, selected optical properties, heterostructures, effective mass, quantum wells, two-dimensional electron gas, quantum wires, deep levels, crystal binding.

216B. Defects in Semiconductors
(4) PETROFF

Prerequisites: ECE 162A-B.

Same course as Materials 216. Lecture, 3 hours.

Structural and electronic properties of elementar defects in semiconductors. Point defects and impurity complexes. Deep levels. Dislocations and grain boundary electronic properties. Measurement techniques for radiative and nonradiative defect centers.

217. Molecular Beam Epitaxy and Band Gap Engineering
(3) GOSSARD

Prerequisites: ECE 162A-B and 213.

Same course as Materials 217. Lecture, 3 hours.

Fundamentals and recent research developments in the growth and properties of thin crystalline films of electronic and optical materials by the process of molecular beam epitaxy. Artificially structured materials with quantized electron confinement and artificially engineered electronic band structure properties.

218A. Communication Electronics
(4) LONG

Prerequisites: ECE 137A-B or equivalent.

Analog communication circuits 1 MHz to 1 GHz with emphasis on receivers. S-parameter design techniques, nonideal components, distortion, amplifier design and characterization, system level analysis.

218B. Communication Electronics
(4) LONG

Prerequisite: ECE 218A.

Analog communication circuits 1 MHz to 1 GHz with emphasis on receivers. Design and evaluation of RF components: mixers, oscillators, PLL, IF amplifier, FM demodulator, frequency synthesis.

218C. High Speed Bipolar Mixed Signal and Communication IC Design
(4) RODWELL

Prerequisites: ECE 137A-B or equivalent; graduate standing.

Transistor and passive component models. Broadband amplifier design. Fast digital IC design at the transistor level. Circuit noise, signal/noise ratios, digital communication receiver sensitivity. Latched comparator design. Nyquist and oversampled analog-digital and digital-analog converters. Direct digital frequency synthesis. Fiber optic and microwave digital transceivers.

219. CMOS & RF INTEGRATED CIRCUIT DESIGN
(4) YUE

Prerequisite: ECE 137A and 137B.

Recommended Preparation: ECE 145A/218A and ECE 145B/218B.

Covers the design and analysis of radio-frequency integrated systems at the transistor level using state-of-the-art CMOS technology. Focuses on system-level trade-offs in transceiver design, practical RF circuit techniques, and physical understanding for device parasitics.

220A. Semiconductor Device Processing
(4) STAFF

Prerequisite: ECE 132 or equivalent.

Same course as Materials 215A. Lecture, 3 hours; discussion, 1 hour.

Intensive theoretical and laboratory instruction in solid-state device and integrated circuit fabrication. Topics include 1) semiconductor material properties and characterization; 2) phase diagrams; 3) diffusion; 4) thermal oxidation; 5) vacuum processes; 6) thin-film deposition; 7) scanning electron microscopy. Both gallium arsenide and silicon technologies are presented.

220B-C. Semiconductor Device Processing
(4-4) HU

Prerequisite: ECE 220A.

Same course as Materials 215B-C. Lecture, 3 hours; discussion 1 hour.

Continued theoretical and laboratory instruction in the fundamentals, the design, the fabrication, and the characterization of junction and field-effect devices. Topics will include bipolar characterization, design, fabrication, and testing. The laboratory effort initiated in ECE 220A will be continued in these two quarters.

221A. Semiconductor Device Physics I
(4) MISHRA

Prerequisites: ECE 132 and 162A-B. Lecture, 4 hours.

Band diagrams of P-N junctions and heterojunctions; current flow by drift and diffusion; bipolar transistors; recombination and generation. Schottky barriers; heterostructures.

221B. Semiconductor Device Physics II
(4) MISHRA

Prerequisites: ECE 215A and 221A. Lecture, 4 hours.

More advanced continuation of ECE 221A: field effect transistors, quantum wells and superlattices; tunneling; avalanche breakdown; physical limitations of bipolar and field effect transistors; two-dimensional current flow problems.

224A. VLSI Project Design
(4) BREWER

Prerequisite: ECE 124A or equivalent and ECE 124D/256C

Design, planning and layout of a CMOS/ Mixed-Signal VLSI Integrated Circuit for fabrication, characterization and test. Layout rules, topological, and physical issues in the design of integrated systems. Student teams plan, design and test a VLSI project.

224B. VLSI Project Testing
(4) BUTNER

Prerequisite: ECE 224A. Lecture, 2 hours; laboratory, 2 hours.

Test equipment and testing techniques. Methods for diagnosing design problems. Students perform laboratory testing of their fabricated designs from ECE 224A.

225. High Speed Digital Integrated Circuit Design
(4) BANERJEE

Prerequisite: ECE 124A or 137A. Lecture, 4 hours.

Advanced digital VLSI design: CMOS scaling, nanoscale issues including variability, thermal management, 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.

226. Level Set Methods
(4) GIBOU

Prerequisite: Computer Science 211C or Chemical Engineering 211C or ECE 210C or ME 210C.

Same course as Chemical Engineering 226, Computer Science 216, and ME 216.

Mathematical description of the level set method and design of the numerical methods used in its implementations (ENO-WENO, Godunov, Lax-Friedrich, etc.). Introduction to the Ghost Fluid Method. Applications in CFD. Materials Sciences, Computer Vision and Computer Graphics.

227A. Semiconductor Lasers I
(4) COLDREN

Prerequisites: ECE 162A-B-C or 144. Lecture, 4 hours.

Review of semiconductor physics, growth technology, and materials properties; double-heterostructure and quantum-well laser structures; carrier and photon rate equations; light vs. current characteristics; scattering and transmission matrices; compound cavity, distributed Bragg reflector, and distributed feedback lasers.

227B. Semiconductor Lasers II
(4) COLDREN

Prerquisites: ECE 227A and 215A. Lecture, 4 hours.

Gain and spontaneous emission vs. injection current in semiconductors; nonradiative recombination; strained-layer quantum wells. Dynamic characteristics of lasers including differential and large signal analysis of the rate equations; relative intensity noise and linewidth; carrier transport and feedback effects.

227C. Photonic Integrated Circuits
(4) COLDREN

Prerequisites: ECE 227A-B. Lecture, 4 hours.

Perturbation and coupled-mode analysis; DFB lasers revisited; directional couplers; modal excitation. Dielectric waveguide analysis techniques; waveguide radiation losses. Photonic integrated circuit examples, including tunable lasers with in-line gratings and contra- and co-directional couplers; ring lasers; numerical analysis techniques.

228A. Fiber Optic Communications
(4) BOWERS

Prerequisites: ECE 162A-B-C, 135, 144. Lecture, 4 hours.

Optical fiber structures and guided modes. Effect of dispersion, attenuation and fiber, nonlinearities. Basic transmission design including loss and rise time budgets. Optical transmission system essentials and requirements. Introduction to WDM and TDM components and technologies.

228B. Fiber Optic Components and Systems
(4) BOWERS

Prerequisite: ECE 228A. Lecture, 4 hours.

Photodetector design and receiver characteristics. Optical transmitters, optical amplifiers, optical isolators, optical switches, wavelength converters, regenerators, optical multiplexers, and demultiplexers. Advanced transmission link design and performance including bit error rate and signal to noise ratio and fiber transmission impairments.

228C. Optical Networks
(4) BOWERS

Prerequisite: ECE 228B. Lecture, 4 hours.

Introduction to optical network architectures including long-haul, wide-area, metro and access networks. First generation networks including SONET and Gigabit Ethernet. Second generation networks including optical circuit switched network concepts, control plane, protection switching, routing wavelength assignment, and network management and control.

229. Hybrid Systems
(4) HESPANHA

Prerequisite: graduate standing in mechanical engineering, chemical engineering, electrical & computer engineering, or computer science.

Recommended preparation: ECE 147A or similar course.

Introduction to systems that combine continuous dynamics with discrete logic. Topics include a modeling framework that combines elements from automata theory and differential equations, simulation tools, analysis and design techniques for hybrid systems and applications of hybrid control systems.

230A-B. Linear Systems I, II
(4-4) HESPANHA, BAMIEH

Prerequisites: ME 210A (for 230A): ECE 140; and, ECE 230A or ME 243A; and ME 210A (for 230B).

Same course as ME 243A-B. Lecture, 4 hours.

Internal and external descriptions. Solution of state equations. Controllability and observability realizations. Pole assignment, observers; modern compensator design. Disturbance localizations and decoupling. Least-squares control. Least-squares estimation; Kalman filters; smoothing. The separation theorem; LQG compensator design. Computational considerations. Selected additional topics.

232. Introductory Robust Control with Applications
(4) SMITH, KHAMMASH

Prerequisites: ECE 230A or ME 255A; and ECE 230B or ME 243B (may be taken concurrently).

Same course as ME 256.

Robust Control theory; uncertainty modeling; stabilty of systems in the presence of norm-bounded perturbations; induced norm performance problems;

structured singular value analysis; H-infinity control theory; model reduction; computer simulation based design projectinvolving practical problems.

234. Modeling, Identification, and Validation for Control
(4) SMITH
Prerequisite: ECE 230A. Lecture, 3 hours.
Parametric and non-parametric models, open and closed-loop identification, bias and variance effects, model order selection, probing signal design, subspace identification, closed-loop probing, autotuning, model validation, iterative identification and design.

235. Stochastic Processes in Engineering
(4) ILTIS
Prerequisites: ECE 140; graduate standing. Lecture, 4 hours.
A first-year graduate course in stochastic processes, including: review of basic probability; Gaussian, Poisson, and Wiener processes; wide-sense stationary processes; covariance function and power spectral density; linear systems driven by random inputs; basic Wiener and Kalman filter theory.

236. Nonlinear Control Systems
(4) TEEL
Same course as ME 236.
Recommended preparation: ECE 230A. Lecture, 4 hours.
Analysis and design of nonlinear control systems. Focus on Lyapunov stability theory, with sufficient time devoted to contrasts between linear and nonlinear systems, input-output stability and the describing function method.

237. Nonlinear Control Design
(4) TEEL
Prerequisite: ECE 236 or ME 236.
Same course as ME 237. Lecture, 4 hours.
Stabilizability by linearization and by geometric methods. State feedback design and input/output linearization. Observability and output feedback design. Singular perturbations and composite control. Backstepping design of robust controllers for systems with uncertain nonlinearities. Adaptive nonlinear control.

238. Advanced Control Design Laboratory
(4) SMITH
Prerequisites: ECE 230A; and, ECE 232A or ECE 237 or ME 237 or ECE 249 or ME 270A or Chemical Engineering 252. Lecture, 2 hours; laboratory, 6 hours.
A laboratory course requiring students to design and implement advanced control systems on a physical experiment. Experiments from any engineering or scientific discipline are chosen by the student.

240A. Optimal Estimation and Filtering
(4) SHYNK
Prerequisites: ECE 140 and 210A. Lecture, 4 hours.
Optimal estimation concepts and theory (minimum variance, least-squares, and maximum likelihood estimation), optimal recursive algorithms for discrete- and continuous-time filtering of noisy signals and data. Wiener and Kalman filters, stability of recursive optimal filtering algorithms, modeling errors in recursive filters.

241. Multimedia Compression
(4) GIBSON
Prerequisites: ECE 140 or 235; and ECE 158.
Not open for credit to students who have completed MAT 221. Lecture, 4 hours.
Covers the principle standards of speech, audio, still image and video compression with emphasis on system performance, key underlying algorithms and technologies, current applications and the projected future evolution of the standards.

242. Digital Signal Compression
(4) ROSE
Prerequisites: ECE 140 or 235; and ECE 146B. Lecture, 3 hours.
Principles and techniques of signal compression systems. Basic quantization theory, linear prediction, predictive coding, transform and subband coding, entropy coding, and vector quantization. Techniques and algorithms for efficient trade-offs between fidelity, bit-rate, and complexity. Applications to speech, audio, image and video compression.

243A. Digital Communication Theory
(4) SHYNK
Prerequisite: ECE 146B. Lecture, 4 hours.
Review of probability and random waveforms, optimum receiver principles, efficient signaling, bounds on error probability, convolutional coding, channel capacity, emphasis on geometric approach to signal description.

243B. Advanced Digital Communication Theory
(4) SHYNK
Prerequisite: ECE 243A. Lecture, 4 hours.
Bandlimited channels and optimum receiver for ISI channels; linear, decision-feedback, blind, and adaptive equalization; multichannel and multicarrier systems; spread-spectrum signals; direct sequence and frequency hopped; fading multipath channels and diversity techniques; multiuser communications.

245. Adaptive Filter Theory
(4) SHYNK
Prerequisites: ECE 140, 158, and 210A (may be taken concurrently). Lecture, 4 hours.
Theory and analysis of adaptive filters. Optimal filtering, linear prediction, method of least squares. Steepest-descent and Newton search methods, gradient estimation, LMS adaptive algorithm, recursive least squares. Gradient and least-squares lattice algorithms for joint-process estimation. Convergence analysis, stability conditions, time constants, misadjustment. (offered in alternate years.)

247. System Identification
(4) STAFF
Prerequisite: ECE 230A. Lecture, 4 hours.
On-line identification of continuous- and discrete-time systems. Linear parameterizations. Continuous gradient and least squares algorithms. Stability, persistent excitation and parameter convergence. Robust algorithms for imperfect models. Averaging. Discrete-time equation-error identifiers. Output-error methods.

248. Kalman and Adaptive Filtering
(4) STAFF
Prerequisites: ECE 210A, 230A and 235 (may be taken concurrently). Lecture, 4 hours.
Least-squares estimation for processes with state-space models. Wiener filters and spectral factorization. Kalman filters, smoothing and square-root algorithms. Steady-state filters. Extended Kalman filters for non-linear models. Fixed-order and order-recursive adaptive filters.

249. Adaptive Control Systems
(4) KOKOTOVIC
Prerequisites: ECE 236 and 247. Lecture, 4 hours.
Models of plants with unknown parameters. Boundedness properties of parameter update laws. Adaptive linear control. Stability and robustness to modeling errors and disturbances. Backstepping state-feedback design of direct adaptive nonlinear control. Output-feedback design. Nonlinear swapping. Indirect adaptive nonlinear control.

250. Wireless Communication and Networking
(4) RODOPLU
Prerequisites: ECE 155A and 146A. Lecture, 4 hours.
Overview of wireless networks, characteristics of wireless medium, physical layer operation (spread spectrum, UWB, OFDM, adaptive modulation, MIMO channel), cellular planning, mobility management, energy-efficient networking, GSM, CDMA, wireless LANs, ad hoc networks, wireless geolocation systems.

252B. Computer Arithmetic
(4) PARHAMI
Prerequisites: ECE 152A-B. Lecture, 4 hours.
Standard and unconventional number representations. Design of fast two-operand and multi-operand adders. High-speed multiplication and division algorithms. Floating-point numbers, algorithms, and errors. Hardware algorithms for function evaluation. Pipelined, digit-serial, and fault-tolerant arithmetic processors.

253. Embedded System Design
(4) BREWER
Lecture, 4 hours.
Design and application of embedded computing systems, particular attention paid to computation system design in highly constrained environments. System synthesis and modeling techniques including partitioning, scheduling, control and data flow analysis and functional representation. Embedded project design.

254A. Advanced Computer Architecture: Supercomputers
(4) MELLIAR-SMITH
Prerequisite: ECE 154. Lecture, 4 hours.
Design and application aspects of high-performance uniprocessors and shared memory multiprocessors. Memory design issues: cache memories, address translation, interleaving. Processor design issues: instruction sets, pipelining, vector processing. Software issues: explicit/implicit vectorization, vector-processing languages, optimizing compilers. Case studies of designs and applications.

254B. Advanced Computer Architecture: Parallel Processing
(4) PARHAMI
Prerequisite: ECE 254A. Lecture, 4 hours.
The nature of concurrent computations. Idealized models of parallel systems. Practical realization of concurrency. Interconnection networks. Building-block parallel algorithms. Algorithm design, optimality, and efficiency. Mapping and scheduling of computations. Example multiprocessors and multicomputers.

254C. Advanced Computer Architecture: Distributed Systems
(4) MELLIAR-SMITH
Prerequisite: ECE 254A.
Multicomputers and distributed architectures. Message-based asynchronous computations. Distributed algorithms and their performance. Hardware issues: nodes, links, and communication mechanisms. Control issues: synchronization, global state determination, distributed consensus, and fault tolerance. Software issues: operating systems and languages.

255A. VLSI Testing Techniques
(4) CHENG
Prerequisites: ECE 152A, knowledge of C language, data structures and algorithms. Lecture, 4 hours.
Concepts, algorithms and design techniques for VLSI testing. Fault modeling, fault simulation, automatic test generation, design for testability, built-in self test, testability analysis, delay testing and synthesis for testability.

255B. VLSI Design Validation
(4) WANG
Prerequisites: ECE 255A, knowledge of C language, data structures and algorithms; consent of instructor. Lecture, 4 hours.
Theories and concepts in verification. Verification tools and methodologies. Functional verification, equivalence checking, symbolic simulation, error modeling, verification coverage, silicon debug, on-chip validation, test and verification.

256A. Introduction to Design Automation
(4) MAREK-SADOWSKA
Prerequisites: ECE 124A or ECE 224A; knowledge of C language; Algorithms and Data Structures, equivalent to Computer Science 130A-B. Lecture, 3 hours; laboratory, 2 hours.
Overview of physical level design automation. Partitioning, placement, routing and structured design of VLSI and PC-board structures. Techniques will include graph theoretic algorithms, integer linear programming, force-directed and simulated annealing neuristics.

256B. Logic Design Automation
(4) BREWER
Prerequisite: ECE 256A. Lecture, 3 hours; laboratory, 2 hours.
CAD algorithms for VLSI logic and module level design. Special attention paid to timing, area, and power trade-offs. Cell design systems and associated lab with state of the art VLSI design tools. (W)

256C. Advanced VLSI Architecture and Design
(4) STAFF
Prerequisite: ECE 124A or equivalent or ECE 256A or 256B

Large scale VLSI design with attention to performance constraints in real-world designs. Topics include: circuit modeling, communication parasitics, architecture optimization, and packaging. Large scale project will be fabricated using silicon compilation tools.

256D. Algorithmic Logic Synthesis
(4) MAREK-SADOWSKA
Prerequisite: ECE 256A. Lecture, 4 hours.
Companion course for ECE 256B. Algorithmic extension of logic synthesis and techniques. Topics covered include: two and multilevel minimization, technology mapping, logic partitioning, and testable logic.

257A. Fault Tolerant Computing
(4) PARHAMI
Prerequisites: ECE 152A-B. Lecture, 3 hours.
Basic concepts of dependable computing. Reliability of nonredundant and redundant systems. Dealing with circuit-level defects. Logic-level fault testing and tolerance. Error detection and correction. Diagnosis and reconfiguration for system-level malfunctions. Degradation management. Failure modeling and risk assessment.

258A. Advanced Digital Signal Processing
(4) STAFF
Prerequisite: ECE 158. Lecture, 4 hours.
Digital filter design, discrete random signals, effects of finite word length arithmetic, fast Fourier transform and applications, power spectrum estimation.

258B. Multirate Digital Signal Processing
(4) STAFF
Prerequisites: ECE 158 and ECE 258A. Lecture, 4 hours.
Multirate digital filter theory, polyphase decomposition, decimator and interpolar design, efficient implementations, orthogonal transforms, wavelet transform, analysis and synthesis filter banks, quadrature mirror filter banks, transmultiplexer, subhand decomposition, applications.

258C. VLSI Digital Signal Processing Systems
(4) STAFF
Prerequisites: ECE 158 and ECE 258A. Lecture, 4 hours.
Characteristics and representations of signal processing programs, iteration bound, pipelining and parallel processing, retiming and unfolding transformations, fast convolution algorithms, algorithmic strength reductions in filters and transforms. (offered every even-numbered year)

259A. Digital Speech Processing
(4) RABINER
Prerequisite: ECE 158 and ECE 242. Lecture, 4 hours.
Speech sounds, acoustic phonetics, speech production and perception. Digital filter modeling of the vocal tract as a lossless tube. Short-time characteristics of speech in the time and frequency domains. Waveform and linear predictive coding of speech. Speech synthesis and recognition.

259B. Fundamentals of Speech Recognition
(4) RABINER
Prerequisite: ECE 158 and ECE 242. Lecture, 4 hours.
Course covers the fundamental design principles of automatic speech recognition systems, including speech detection, time alignment and normalization (including dynamic time warping methods), distortion measures, the Hidden Markov Model (HMM), grammar networks and the use of Finite State Network representations. (Offered alternate years.)

260A. Principles of Quantum Electronics
(4) YEH
Prerequisite: ECE 144A or 162C. Lecture, 4 hours.
Energy levels in atoms, ions, and molecules. Interaction between radiation and quantized systems. Stimulated emission devices. Optical resonators. Lasers. (offered alternate years)

267. Confined Electrons and Photons in Semiconductor Structures
(3) PETROFF
Prerequisite: Materials 162A-B or ECE 162A-B.
Same course as Materials 267. Lecture, 3 hours.
The properties of 1D, 2D and 3D confined electrons in semiconductor are reviewed. Properties of photons in microcavities and photonic crystals are introduced. Applications of photonic crystals to light extraction and modifications of the emitter properties are developed.

270. Noncooperative Game Theory
(4) HESPANHA
Lecture, 4 hours.
Formulation of problems as mathematical games and provides the basic tools to solve them. Covers both static and dynamic games. Intended for graduate students (but is not restricted to) in communications, controls, signal processing, and computer science.

271A. Principles of Optimization
(4) CHANDRABEKARAN
Prerequisite: ECE 210A (may be taken concurrently). Lecture, 4 hours.
Linear programming: simplex and revised simplex method, duality theory, primal-dual algorithms, Karmarkar's algorithm. Network flow problems: max-flow/min-cut theorem, Ford-Fulkerson algorithm, shortest path algorithms. Complexity and NP-completeness theory: the classes of P and NP, reductions between NP-complete problems, pseudopolynomial and approximation algorithms.

271B. Numerical Optimization Methods
(4) STAFF
Prerequisite: ECE 210A. Lecture, 4 hours.
Unconstrained nonlinear problems: basic properties of solutions and algorithms, global convergence, convergence rate, and complexity considerations. Constrained nonlinear problems: basic properties of solutions and algorithms. Primal, penalty and barrier, cutting plane, and dual methods. Computer implementations.

271C. Optimal Control of Dynamic Systems
(4) BAMIEH
Prerequisite: ECE 230A or ME 243A or equivalent
Calculus of variations and Gateaux and Frechet derivatives. Optimization in dynamic systems and Pontryagin's principle. Invariant Imbedding and deterministic and stochastic Dynamic Programming. Numerical solutions of optimal control problems. Min-max problems and differential games. Extensive treatment of Linear Quadratic Problems.

277B. Pattern Recognition
(4) ROSE
Prerequisites: ECE 130C and 140. Lecture, 4 hours.
Principles and design of pattern recognition systems. Statistical classifiers: discriminant functions; Bayes, minimum-risk, k-nearest neighbors, perceptrons. Clustering and estimation; criteria; k-means, fuzzy, hierarchical, graph-theoretic, simulated and deterministic annealing; maximum likelihood and Bayesian methods; nonparametric methods. Overview of applications.

278A. Digital Image Processing
(4) MANJUNATH
Prerequisite: ECE 158 or ECE 178. Lecture, 3 hours; laboratory, 3 hours.
Two-dimensional signals and systems. Two-dimensional Fourier and z-transforms. Discrete Fourier transform, two-dimensional digital filters. Image processing basics, image enhancement and restoration. Special image processing software available for laboratory experimentation.

278C. Imaging Systems
(4) LEE
Prerequisites: ECE 158 and 178. Lecture, 4 hours.
Generalized holography, backward techniques, resolution limit, X-ray tomography, diffraction tomography, NMR imaging, synthetic-aperture radar, active sonar imaging, acoustic microscopy, imaging algorithms, motion estimation and tracking.

279. Computer System Performance Evaluation
(4) STAFF
Prerequisite: ECE 140, ECE 154, and Computer Science 170.
Overview of the evaluation of comput er system performance. Measurement, simulation, and analytic techniques for performance analysis. System work load characterization. Examples of performance evaluation for system selection, tuning, and design. Evaluation of program performance.

281B. Advanced Topics in Computer Vision
(4) MANJUNATH
Prerequisite: ECE 181B. Lecture, 3 hours.
Same course as Computer Science 281B.
Advanced topics in computer vision: image sequence analysis, spatiotemporal filtering, camera calibration and hand-eye coordination, robot navigation, shape representation, physically-based modeling, multi-sensory fusion, biological models, expert vision systems, and other topics selected from recent research papers.

282. Error Correcting Codes
(4) ROSE
Prerequisite: ECE 130C or 140. Lecture, 3 hours.
Principles and techniques for combating channel errors in data transmission or storage. Introduction to Galois fields. Linear block codes (particularly Hamming, BCH, Reed-Solomon). Convolution codes. Encoding and decoding algorithms (including spectral methods, maximum likelihood and Viterbi decoding.)

290. Ethics in Academic and Industrial Research
(2) SMITH
Prerequisite: consent of instructor. Lecture, 2 hours.
Case study/analysis format addressing ethical issues in research conduct: moral reasoning, authorship, scholarship, copyright, misconduct, fraud, falsification, mentor/protege relationships, confidentiality, patents, consulting, conflicts of interest, funding and control of research, reviewing and editing, sexual relationships in the workplace.

293. Internship in Industry
(1-6) STAFF
Prerequisite: consent of department.
May be repeated to a maximum of 6 units. Variable hours.
Special projects for selected students. Offered in conjunction with engineering practice in selected industrial and research firms, under direct faculty supervision.

295. Group Studies: Controls, Dynamical Systems, and Computation
(1) STAFF
Same course as Chemical Engineering 295, Computer Science 592, and ME 295. Seminar, 1 hour.
A series of weekly lectures given by university staff and outside experts in the fields of control systems, dynamical systems, and computation.

493. Internship in Industry
(1-12) STAFF
Prerequisite: Graduate student standing; open to EE and computer engineering majors only.
Special projects for selected students. Offered in conjunction with engineering practice in selected industrial and research firms, under direct faculty supervision.

502. Teaching of Electrical and Computer Engineering
(1-4) STAFF
Open to electrical and computer engineering teaching assistants only. No unit credit allowed toward advanced degree. Variable hours.
Procedures and techniques for teaching electrical engineering or computer engineering gained through actual teaching of lecture courses, leading discussion sections, and/or teaching engineering laboratories. Meetings will be held as needed to discuss problems, methods, and procedures.

594AA-ZZ. Special Topics in Electrical and Computer Engineering
(1-5) STAFF
Prerequisites: consent of instructor and graduate status.
May be repeated for credit if there is no duplication of course content. Seminar, 1-5 hours.
Instruction in these courses may be carried out by lecture, or by laboratory, or by a combination of these. These courses provide a study of topics of current interest in various areas of electrical and computer engineering. Special topics are coded as follows (check with department for quarters offered):

A. Circuits
AA. Micro-Electro-Mechanical Systems
B. Systems Theory
BB. Computer Engineering
C. Communication Systems
D. Control Systems
E. Signal Processing
F. Solid State
G. Fields and Waves
H. Quantum Electronics
I. Microwave Electronics
J. Switching Theory
K. Digital Systems Design
L. Computer Architecture
M. Computer Graphics
N. Pattern Recognition
O. Microprocessors and Microprocessor-based Systems
P. Simulation
Q. Imaging Systems and Image Processing
R. General
S. Speech
T. Robot Control
U. Optoelectronics
V. Scientific Computation
W. Computer Network
X. Distributed Computation
Y. Numerical Differential Equations
Z. Nanotechnology

595AA-ZZ. Group Studies in Electrical and Computer Engineering
(1) STAFF
Prerequisite: consent of instructor.
No unit credit allowed toward degree. May be repeated for enrollment credit if there is no duplication of course content. Seminar, 1 hour.
Instruction in research group meetings carried out by lecture, by laboratory, or by a combination of the two. Courses provide a critical review of research in various areas of electrical and computer engineering.

596. Directed Research
(2-12) STAFF
Research, either experimental or theoretical, May be undertaken by properly qualified graduate students under the direction of a faculty member.

597. Individual Studies for M.S. Comprehensive Examinations and Ph.D. Examinations
(1-12) STAFF
No unit credit allowed toward advanced degree. Enrollment limited to 24 units per exam.
Individual studies for M.S. comprehensive examinations and Ph.D. examinations. Maximum of 12 units per quarter. S/U grading. Instructor is normally student's major professor or chair of doctoral committee.

598. Master's Thesis Research and Preparation
(1-12) STAFF
Prerequisite: consent of graduate advisor.
For research underlying the thesis and writing of the thesis.

599. Ph.D. Dissertation Research and Preparation
(1-12) STAFF
Prerequisite: consent of chair of student's doctoral committee.
Research and preparation of dissertation.

Engineering Sciences

Engineering Sciences, Office of the Associate Dean for Undergraduate Studies, Harold Frank Hall, Room 1006;
Telephone (805) 893-2809
Web site: www.engr.ucsb.edu/current_undergraduates/engr_sci/

Chair & Associate Dean for Undergraduate Studies: Glenn E. Beltz
Associate Dean for Technology Management Programs: Gary S. Hansen

Faculty

* **Kevin C. Almeroth,** Ph.D., Georgia Institute of Technology, Professor

Glenn E. Beltz, Ph.D., Harvard, Professor

* **John E. Bowers,** Ph.D., Stanford University, Professor

* **Steven P. DenBaars,** Ph.D., University of Southern California, Professor

Edward N. Dodson, Ph.D., Stanford University, Lecturer

* **Gary S. Hansen**, Ph.D., University of Michigan, Associate Professor

* **Keith T. Kedward,** Ph.D., University of Wales, Professor

* **David Seibold,** Ph.D., Michigan State University, Professor

** Technology Management Program faculty*

The Engineering Sciences program at UCSB 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.

Engineering Sciences Courses

LOWER DIVISION

3. Introduction to Matlab and C Programming
(3) STAFF
Prerequisites: Open to chemical engineering, electrical engineering, and mechanical engineering majors only.
General philosophy of programming for engineering majors, with introductions to Matlab, the C programming language, and the Linux operating system.

10H. Engineering Honors Seminar
(1) BELTZ, TIRRELL, MISHRA, HANSEN
Prerequisites: enrollment in College of Engineering Honors Program; lower-division standing.
An interdisciplinary examination of selected topics, texts, theories, and/or methods in engineering. Particular course focus is determined by the instructor(s) each time the course is offered.

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-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. Engineering Economic Analysis
(3) DODSON
Prerequisite: Upper-division standing in Engineering.
Integration of economics into the evaluation of engineering projects; economic considerations in engineering project management and decision-making.

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. (W,S)

102AA-ZZ. Special Topics in Engineering, Business, and Society
(1) STAFF
Prerequisites: Upper-division standing.
May be repeated for credit if there is no duplication of course content.
A series of weekly lectures given by university staff and outside experts in all fields of new technology management.

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. May be repeated for credit to a maximum of 12 units, but only 4 units may be applied to the major.
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.

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.

182. Introduction to Health Care and Biomedical Technology
(3) KOHL
Prerequisite: upper-division standing.
Same course as MCDB 182.
Course offered in conjunction with Sansum-Santa Barbara Clinic and Cottage Hospitals and involves a series of lecture/discussions dealing with various aspects of health delivery and modern biotechnology. Students spend time working with a physician or medical research scholar.

185A. The Art of the CEO: Business Skills for Future Leaders
(4) HANSEN
Prerequisite: Writing 2 or 2E; and,
Writing 50 or 50E or 109AA-ZZ; senior standing.

An introductory business course in strategic thinking, negotiations, marketing, finance and modeling skills that prepare engineering, science and non-technical students for successful entry into business. Class uses case studies, lectures, and computer simulation.

185B. New Venture Creation: Entrepreneurship
(4) HANSEN
Prerequisite: Writing 2 or 2E; and, Writing 50 or 50E or 109AA-ZZ; senior standing.
Overview of the new venture creation process. Analysis of new business opportunities, development of new business value propositions, team building, venture financing, new venture planning, managing and protecting intellectual property, business formation, and other topics relevant to the entrepreneurial process.

185C. Business Planning for New Technology Ventures
(4) HANSEN
Prerequisite: Engineering 185A; and, Engineering 185B or 185D; senior standing.
Analysis and creation of a business plan for a new business venture including demand forecasting, financial modeling, selling of the new business idea, and other issues for current business conditions.

185D. New Product Development
(4) BOWERS
Prerequisite: senior standing.
New product development requires technical and non-technical business persons to work across disciplines. Instruction is provided in a wide range of topics concerning customer driven product innovation. Students learn new product development processes, tools, techniques and organizational structures.

185F. Business Skills: Asia: New Opportunities for Technology Businesses
(4) STAFF
Prerequisite: Upper-division standing.
Use analytical frameworks for assessing technology business environments and sustainability within Asia. Establish historical context; governmental structures, policy and influence; capability investments and yield by local and foreign companies; operating models in leveraging Asian economies' resources and related experiences. .

191AA-ZZ. Professional Seminar in New Technology Management
(2) STAFF
Prerequisite: Upper-division standing.
May be repeated for credit if there is no duplication of course content.
Courses provide for the study of topics of current interest in the areas of entrepreneurship, business, engineering management, ethics, social, political, and other issues related to the successful practice of engineering.

192A. Entrepreneurial Opportunities in Healthcare and Life Sciences
(2) STAFF
Prerequisite: senior standing.
Not open for credit to students who have completed Engineering 191F.
Expert guest lecturers address current products and services. Students address the identification of market opportunities with an appreciation of the needs and requirements of the healthcare industry.

192B. Designing Solutions for Healthcare and Life Sciences Opportunities
(2) STAFF
Prerequisite: senior standing.
Students identify specific solutions for business opportunities in the healthcare industry considering technological and market feasibility. Interaction with healthcare professionals and industry executives.

192C. Critical Issues in Early Stage Healthcare and Life Science Companies
(2) STAFF
Prerequisite: senior standing.
Course includes visiting speakers and field visits to facilitate learning about the critical issues in early stage, life science related companies.

193A. Entrepreneurial Opportunities in IT and Telecom
(2) STAFF
Prerequisite: Upper-division standing.
This course is intended for students with an interest in the identification of new products and services in the IT and Telecom environment. The course involves interaction with industry professionals and executives.

193B. Designing Solutions for IT and Telecom
(2) STAFF
Prerequisite: Upper-division standing.
Students design specific solutions for business opportunities in the IT and Telecom industry considering technological and market feasibility.

193C. Critical Issues in Early Stage IT and Telecom Companies
(2) STAFF
Prerequisite: Upper-division standing.
Course includes visiting speakers and field visits to facilitate learning about the critical issues in early stage Telecom related companies.

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

202AA-ZZ. Special Topics in Engineering, Business and Society
(1) STAFF
Prerequisite: graduate standing.
May be repeated for credit if there is no duplication of course content.
A series of weekly lectures given by university staff and outside experts in all fields of new technology management.

285A. The Art of the CEO: Business Skills for Future Leaders
(4) HANSEN
An introductory business course in strategic thinking, negotiations, marketing, finance and modeling skills that prepare engineering, science and non-technical students for successful entry into business. Uses case studies, lectures, and computer simulation.

285B. New Venture Creation: Entrepreneurship
(4) HANSEN
Overview of the new venture creation process. Analysis of new business opportunities, development of new business value propositions, team building, venture financing, new venture planning, managing and protecting intellectual property, business formation, and other topics relevant to the entrepreneurial process.

285C. Business Planning for New Technology Ventures
(4) HANSEN
Prerequisites: Engineering 285A; and, Engineering 285B or 285D.
Analysis and creation of a business plan for a new business venture including demand forecasting, financial modeling, selling of the new business idea and other issues for current business conditions.

285D. New Product Development
(4) BOWERS
New product development requires technical and non-technical business persons to work across disciplines. Instruction is provided in a wide range of topics concerning customer driven product innovation. Students learn new product development processes, tools, techniques and organizational structures.

285E. Managing for Innovation
(4) SEIBOLD
Prerequisite: graduate standing.
Examination of communication and key management functions: envisioning and strategic planning; creating high performance teams; establishing appraisal/reward systems; innovation and organizational change. Emphasis on leading innovative technical people; leadership that fosters entrepreneurship and intrapreneurship; new forms of organizing.

285F. Business Skills: Asia: New Opportunities for Technology Businesses
(4) STAFF
Prerequisite: graduate standing.
Students use analytical frameworks for assessing technology business environments and sustainability within Asia. Establish historical context; governmental structures, policy and influence; capability investments and yield by local and foreign companies; operating models in leveraging Asian economies' resources and related experiences.

291AA-ZZ. Professional Seminar in New Technology Management
(2) STAFF
May be repeated for credit if there is no duplication of course content.
Courses provide for the study of topics of current interest in the areas of entrepreneurship, business, engineering management, ethics, social, political, and other issue related to the successful practice of engineering.

292A. Entrepreneurial Opportunities in Health Care and Life Sciences
(2) STAFF
Expert guest lecturers address current products and services. Students address the identification of market opportunities with an appreciation of the needs and requirement of the healthcare industry.

292B. Designing Solutions for Healthcare and Life Sciences Opportunities
(2) STAFF
Students identify specific solutions for business opportunities in the healthcare industry considering technological and market feasibility. Interaction with healthcare professionals and industry executives.

292C. Critical Issues in Early Stage Healthcare and Life Science Companies
(2) STAFF
Course includes visiting speakers and field visits to facilitate learning about the critical issues in early stage, life-science related companies.

293A. Entrepreneurial Opportunities in IT and Telecom
(2) STAFF
Prerequisite: graduate standing.
Intended for students with an interest in the identification of new products and services in the IT and Telecom environment. The course involves interaction with industry professionals and executives.

293B. Designing Solutions for IT and Telecom
(2) STAFF
Prerequisite: graduate standing.
Students design specific solutions for business opportunities in the IT and Telecom industry considering technological and market feasibility.

293C. Critical Issues in Early Stage IT and Telecom Companies
(2) STAFF
Prerequisite: graduate standing.
Course includes visiting speakers and field visits to facilitate learning about the critical issues in early stage Telecom related companies.

Materials

Department of Materials
Engineering II, Room 1355;
Telephone (805) 893-4362
Web site: www.materials.ucsb.edu

Chair: James S. Speck
Associate Chair: Francis W. Zok

Faculty

Guillermo C. Bazan, Ph.D., Massachusetts

Institute of Technology, Professor (polymer synthesis, photophysics) *5

Michael Chabinyc, Ph.D., Stanford University, Professor (organic semiconductors, thin film electronics, energy conversion using photovoltaics, characterization of thin films of polymers, x-ray scattering from polymers)

David R. Clarke, Ph.D., University of Cambridge, Professor (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

Steven P. DenBaars, Ph.D., University of Southern California, Professor (metalorganic chemical vapor deposition (MOCVD) of semiconductors, IR to blue lasers and LEDs, high power electronic materials and devices) *1

Anthony Evans, Ph.D., Imperial College, London, Professor, Director of Center for Multifunctional Materials and Structures (thermostructural materials, ultralight structures, multifunctional materials and devices, actuating structures) *2

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

Craig Hawker, Ph.D., University of Cambridge, Professor, Director of Materials Research Laboratory (synthetic polymer chemistry, nonotechnology, materials science) *5

Alan J. Heeger, Ph.D., UC Berkeley, 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, Director of Institute for Quantum Engineering, Science, and Technology, Scientific Co-Director of California NanoSystems Institute (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, Professor (adhesion, friction surface forces, colloids, biosurface interactions) *3

Edward J. Kramer, Ph.D., Carnegie Mellon University, Professor (fracture and diffusion in polymers; polymer surfaces, interfaces, and thin films) *3

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

Frederick F. Lange, Ph.D., Pennsylvania State University, ALCOA Professor of Materials (processing, ceramics, microstructure, mechanical properties)

Carlos G. Levi, Ph.D., University of Illinois at Urbana-Champaign, Professor (materials processing, and microstructure evolution, coatings, composites, functional inorganics) *2

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

Robert M. McMeeking, Ph.D., Brown University, Professor (mechanics of materials, fracture mechanics, plasticity, computational mechanics, process modeling) *2

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

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

Chris Palmstrom, Ph.D., University of Leeds, 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

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

Philip A. Pincus, Ph.D., UC Berkeley, Professor (theoretical aspects of self-assembled biomolecular structures, membranes, polymers, and colloids) *4

Cyrus R. Safinya, Ph.D., Massachusetts Institute of Technology, 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)

Ram Seshadri, Ph.D., Indian Institute of Science, Professor (inorganic materials, preparation and magnetism of bulk solids and nonoparticles, patterned materials)

Hyongsuk (Tom) Soh, Ph.D., Stanford, Associate Professor (directed evolution of biological molecules, supramolecular assemblies, integrated biosensors) *2

Nicola A. Spaldin, Ph.D., UC Berkeley, Professor (computational electronic and magnetic materials)

James S. Speck, Sc.D., Massachusetts Institute of Technology, 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, Professor (biomaterials, composites, materials synthesis, electro-optical materials catalysis) *5

Matthew V. Tirrell, Ph.D., University of Massachusetts, Auhll Professor (bioengineering, polymer science and engineering) *3

Chris Van de Walle, Ph.D., Stanford University, Professor (novel electronic materials, wide-band-gap semiconductors, oxides)

Claude Weisbuch, Ph.D., Universite Paris VII, Ecole Polytechnique-Palaiseau, 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)

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)

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, (catalysis, optical materials, X-ray, neutron diffraction) *5

James L. Merz, Ph.D., Harvard University, Professor Emeritus *1

*1 Joint appointment with the Department of Electrical and Computer Engineering.
*2 Joint appointment with the Department of Mechanical Engineering.
*3 Joint appointment with the Department of Chemical Engineering.
*4 Joint appointment with the Department of Physics.
*5 Joint appointment with the Department of Chemistry and Biochemistry.

Affiliated Faculty

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

James S. Langer, Ph.D. (Physics)

L. Gary Leal, Ph.D. (Chemical Engineering)

Glenn E. Lucas, Ph.D. (Chemical Engineering, Mechanical Engineering)

John McTague, Ph.D.

Joseph A. N. Zasadzinski, 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 biosurfaces, 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. The department has close collaborations with, and a number of faculty have joint appointments in, the Departments of Mechanical Engineering (mechanics and design), Chemical Engineering (fluids and environmental effects), Electrical and Computer Engineering (electronic devices), Physics, Chemistry and Biochemistry, and the BMSE Program.

Materials Courses

LOWER DIVISION

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

Not open to engineering, pre-computer science, or computer science majors. Lecture, 3 hours; discussion 1 hour.

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 5A-B-C. Lecture, 3 hours.

An introduction to materials in modern technology. The internal structure of materials and its underlying principles: bonding, spatial organization of atoms and molecules, structural defects. Electrical, magnetic and optical properties of materials, and their relationship with structure.

100B. Structure and Properties II
(3) STAFF

Prerequisite: Materials 100A.

Not open for credit to students who have completed Materials 101. Lecture, 3 hours.

Mechanical properties of engineering materials and their relationship to bonding and structure. Elastic, flow, and fracture behavior; time dependent deformation and failure. Stiffening, strengthening, and toughening mechanisms. Piezoelectricity, magnetostriction and thermo-mechanical interactions in materials.

100C. Fundamentals of Structural Evolution
(3) STAFF

Prerequisites: Materials 100A or ECE 132; and, Materials 100B or Chemical Engineering 185 or ME 180. Lecture, 3 hours.

An introduction to the thermodynamic and kinetic principles governing structural evolution in materials. Phase equilibria, diffusion and structural transformations. Metastable structures in materials. Self-assembling systems. Structural control through processing and/or imposed fields. Environmental effects on structure and properties.

101. Introduction to the Structure and Properties of Materials
(3) STAFF

Prerequisite: upper-division standing.

Not open for credit to students who have completed Materials 100B.

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) STAFF

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) KRAMER

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) HU

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) COLDREN

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) LEVI, ODETTE

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.

186. 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.

GRADUATE COURSES

200A. Thermodynamic Foundation of Materials
(4) KRAMER

Lecture, 4 hours.

The microscopic statistical mechanical foundations of the macroscopic thermodynamics of materials, with applications to ideal and non-ideal gases, electrons and photons in solids, multicomponent solutions, phase equilibria in single and multicomponent systems, and capillarity.

200B. Electronic and Atomic Structure of Materials
(4) VAN DE WALLE

Lecture, 4 hours.

The free electron model; electron levels in periodic potentials. Classification of solids. Role electronic structure in atomic bonding and atomic packing, cohesion. Surfaces, interfaces, and junction effects. Semiconductors. Transition-metal compounds. Amorphous solids. Liquid crystals. Colloids and soft materials.

200C. Structure Evolution
(4) LEVI

Lecture, 4 hours.

Structure evolution. Study of phenomena underlying the evolution of structure across the relevant length and time scales in materials. Structural defects. Driving forces, mechanism and kinetics of structural change. Diffusional transport. Fundamentals of phase transformation. Crystallization. Evolution of microstructural features and patterns.

201. Thermodynamics and Phase Equilibria
(3) STAFF

Prerequisite: consent of instructor.

Same course as ME 262. Lecture, 3 hours.

Advanced thermodynamics with emphasis on phase equilibria, properties of solutions, and multicomponent systems.

203. Transition Metal Oxides
(3) CHEETHAM

Same course as Chemistry 267. Lecture, 3 hours.

Introduction to transition metal oxides. Ligand field theory. Structural basis of magnetism.

204. Introduction to Magnetism and Magnetic Materials
(3) SPALDIN

Review of elementary magnetism magnetostatics. Discussion of atomic origins of magnetism. Properties of ferro-, ferri-, para-, dia-, and antiferro-magnetics, and the theories that describe them. Magnetic phenomena, and magnetic materials in technological applications.

205. Wide-Band Gap Materials and Devices
(3) NAKAMURA

Lecture, 3 hours.

Optical and electrical properties of GaN, ZnSe, SiC, and diamond-based semiconductor materials. Theory and practical application of wide-band gap materials in devices. Materials growth techniques of MOCVD, CVD, and MBE are discussed. Applications of these materials in blue lasers, LEDs (UV, blue, green, and white) are emphasized.

206A. Fundamentals of Electronic Solids I
(4) KROEMER, PETROFF

Prerequisite: ECE 162A-B.

Same course as ECE 215A.

Introduction into the physics of semiconductors for beginning engineering graduate students. Crystal structure. Reciprocal lattice and crystal diffraction. Electrons in periodic structures. Energy and bands. Semiconductor electrons and probes, Fermi statistics.

206B. Fundamentals of Electronic Solids II
(4) GOSSARD

Prerequisite: ECE 162A-B.

Same course as ECE 215B.

Phonons, electron scattering, electronic transport, selected optical properties, heterostructures, effective mass, quantum wells, two-dimensional electron gas, quantum wires, deep levels, and crystal binding.

207. Mechanics of Materials
(3) STAFF

Same course as Mechanical Engineering 219. Lecture, 3 hours.

Matrices and tensors, stress deformation and flow, compatibility conditions, constitutive equations, field equations and boundary conditions in fluids and solids, applications in solid and fluid mechanics.

208. Crystallography and Structure Determination
(3) STAFF

Prerequisite: consent of instructor.

Not open for credit to students who have completed Materials 209B. Lecture, 3 hours.

Topics in structure determination: structure factors, integrated intensities, data collection, the phase problem, patterson synthesis, direct methods, structure refinement, Debye-Waller factors, thermal diffuse scattering and extinction. Rietveld analysis of powder diffraction data. Synchrotron x-rays, neutron diffraction, electron diffraction, non-crystalline materials.

209A. Crystallography and Diffraction Fundamentals
(3) SPECK

Diffraction theory: fourier transformation, schrodinger equation, Maxwell'sequations, kinematical theory, Fresnel diffraction, Fraunhofer diffraction, scattering of x-rays, electrons and neutrons by isolated atoms and assemblies of atoms, pair correlation and radial distribution functions. Basic symmetry operations, point groups, space groups.

209B. X-Ray Diffraction II: Advanced Methods
(3) SPECK

Prerequisite: consent of instructor. Lecture, 3 hours.

Focuses on modern diffraction techniques from crystalline materials. High resolution x-ray diffraction. Analysis of epitaxial layers. X-ray scattering theory. Simulation of x-ray rocking curves. Analysis of thin films and multiple layers. Triple-axis x-ray diffractometry. Topography. Synchrotron techniques.

209BL. X-Ray Diffraction I: Principles and Practice
(3) SESHADRI

Laboratory, 3 hours.

Exposes students to practical aspects of powder and single crystal x-ray diffraction, including the determination and refinement of crystal structures.

209C. Electron Microscopy II: Crystalline Materials
(3) STAFF

Prerequisite: consent of instructor. Lecture, 3 hours.

Electron microscopy to study defect structures, elastic and inelastic scattering, kinematics theory of image contrast, bright and dark field imaging, two-beam conditions, contrast from imperfections, dynamical theory of diffraction and image contrast. Howie Whellan equations, dispersion surface.

209CL. Electron Microscopy I: Principles and Practice
(4) STEMMER

Recommended preparation: students should show a need for TEM in their research. Part of the course involves analysis of student's own samples. Student encouraged to enroll in MATRL 209C before or after MATRL 209CL. Lecture, 2.5 hours; laboratory, 3 hours.

Laboratory course with lecture component. Topics include: TEM alignment, basic functions, electron diffraction and reciprocal space, basic imaging, bright field and dark field, diffraction contrast, quantitative analysis of defects, HRTEM imaging and simulation. Course also involves TEM sample preparation.

211A. Engineering Quantum Mechanics I
(4) STAFF

Prerequisites: ECE 162A-B. Students must have some knowledge of linear algebra.

Same course as ECE 211A. Lecture, 4 hours.

Wave-particle duality; bound states; uncertainty relations; expectation values and operators; variational principle; eigenfunction expansions; perturbation theory I. Treatment matches needs and background of ECE and materials students emphasizing solid state or quantum electronics.

211B. Engineering Quantum Mechanics II
(4) STAFF

Prerequisites: ECE 211A or Materials 211A, or ECE 215A or Materials 206A.

Same course as ECE 211B. Lecture, 4 hours.

Continuation of Materials 211A; symmetry and degeneracy; electrons in crystals, angular momentum; perturbation theory II; transition probabilities; quantized fields and radiative transitions; magnetic fields;electron spin; indistinguishable particles.

214. Advanced Topics in Equilibrium Statistical Mechanics
(3) STAFF

Same course as Chemical Engineering 210B. Not open for credit to students who have completed Chemical Engineering 214.

Recommended preparation: a course in physical chemistry. Lecture, 3 hours.

Application of the principles of statistical mechanics and thermodynamics to treat classical fluid systems at equilibrium. Topics include liquid state theory, computer simulation methods, critical phenomena and scaling principles, interfacial statistical mechanics, and electrolyte theory.

215A. Semiconductor Device Processing
(4) STAFF

Prerequisites: ECE 132 or equivalent.

Same course as ECE 220A. Lecture, 3 hours; discussion, 1 hour.

Intensive theoretical and laboratory instruction in solid-state device and integrated circuit fabrication. Topics include 1) semiconductor material properties and characterization; 2) phase diagrams; 3) diffusion; 4) thermal oxidation; 5) vacuum processes; 6) thin-film deposition; 7) scanning electron microscopy. Both gallium arsenide and silicon technologies are presented.

215B-C. Semiconductor Device Processing
(4-4) GOSSARD, HU

Prerequisite: Materials 215A.

Same course as ECE 220B-C. Lecture, 3 hours, discussion, 1 hour.

Continued theoretical and laboratory instruction in the fundamentals, the design, the fabrication, and the characterization of junction and field-effect devices. Topics will include bipolar characterization, design, fabrication, and testing. The laboratory effort initiated in Materials 215A will be continued in these two quarters.

216. Defects in Semiconductors
(3) STAFF

Prerequisites: ECE 162A-B.

Same course as ECE 216B. Lecture, 3 hours

Structural and electronic properties of elementary defects in semiconductors. Point defects and impurity complexes. Deep levels. Dislocations and grain boundary electronic properties. Measurement techniques for radiative and nonradiative defect centers.

217. Molecular Beam Epitaxy and Band Gap Engineering
(3) GOSSARD

Prerequisites: ECE 162A-B, and 213.

Same course as ECE 217. Lecture, 3 hours.

Fundamentals and recent research developments in the growth and properties of thin crystalline films of electronic and optical materials by the process of molecular beam epitaxy. Artificially structured materials with quantized electron confinement and artificially engineered electronic band structure properties. (normally offered alternate years)

218. Introduction to Inorganic Materials
(3) CHEETHAM

Prerequisite: Chemistry 274.

Same course as Chemistry 277.

Structures of inorganic materials: close-packing, linking of simple polyhedra. Factors that control structure: ionic radii, covalency, ligand field effects, metal-metal bonding, electron/atom ratios. Structure-property relationships in e.g. spinels, garnets, perovskites, rutiles, fluorites, zeolites, B-aluminas, graphites, common inorganic glasses.

219. Phase Transformations
(3) STAFF

Prerequisite: consent of instructor. Lecture, 3 hours.

Introduction to the unifying concepts underlying phas transformations in metals, ceramics, polymers, and electronic materials. Includes the thermodyanamics, kinetics, crystallography and microstructural characteristics of displacive and diffusional transformations. Role of elastics, compositional, configurational, electrical, magnetic and gradientenergy contributions.

220. Mechanical Behavior of Materials
(3) ZOK, ODETTE

Prerequisites: Materials 207; consent of instructor.

Concepts of stress and strain. Deformation of metals, polymers, and ceramics. Elasticity, viscoelasticity, plastic flow, and creep. Linear elastic fracture mechanics. Mechanisms of ductile and brittle fracture.

221. Introduction to Structural Materials
(3) ZOK

Not open for credit to students who have completed Materials 220. Lecture, 3 hours.

Introduction to structure-property relations in engineering materials, including polymers, metals, and ceramics. Elastic, plastic, and creep deformation. Fracture processes. Strengthening and toughening mechanisms.

222A. Colloids and Interfaces I
(3) ISRAELACHVILI

Prerequisite: consent of instructor.

Same course as Chemical Engineering 222A and BMSE 222A. Lecture, 3 hours.

Introduction to the various intermolecular interactions in solutions and colloidal systems: Van der Waals, electrostatic, hydrophobic, solvation, H-bonding. Introduction to colloidal systems: particles, micelles, polymers, etc. Surfaces: wetting, contact angles, surface tension, etc.

222B. Colloids and Interface II
(3) STAFF

Prerequisite: consent of instructor. Lecture, 3 hours.

Continuation of 222A. Interparticle interactions, coagulation, flocculation, DLVO theory, steric interactions, polymer-coated surfaces, polymers in solution, viscosity in thin liquid films. Surfactant self-assembly: micelles, micro-emulsions, lamellar phases, etc. Surfactantson surfaces: Langmuir-Blodgett films, adsorption, adhesion.

224. Optical and Luminescent Materials
(3) CLARKE

Lecture, 2 hours.

Description of the principles underlying the optical and luminescent behavior of materials illustrated with applications drawn from phosphors, optical fibers, optical memories, and electro-optical components and immuno-assay techniques. Fundamental concepts of absorption and emission, and their relation to electronic structure and crystal properties.

225. Introduction to Electronic Materials
(3) SPALDIN

Prerequisite: Materials 100A and 100C or equivalent.

Not open for credit to students who have completed Materials 162B or ECE 162B. Lecture, 3 hours.

Basic quantum mechanics: wave functions and expectation values, free electrons, quantum wells, scattering and tunneling. Basic solid state physics: energy bands in solids, electronic and optical properties of metals and semiconductors. Devices: p-n junctions, transistors, light emitting diodes and lasers.

226. Electrical and Functional Crystals and Ceramics
(3) CLARKE

Lecture, 3 hours.

Description of the principles underlying the behavior of functional crystals and ceramics, ranging from dielectrics, piezoelectrics, ferroelectrics to linear and nonlinear materials. Fundamental concepts, tensorial and mathematical description of functional behavior, point defects, and applications.

227. Metal-Organic Chemical Vapor Deposition
(3) DENBAARS

Lecture, 3 hours.

Electronic and optical properties of thin films grown by vapor phase transport techniques. Growth mechanisms, kinetics and thermodynamics of vapor phase epitaxy. Special emphasis on the process of metalorganic vapor phase epitaxy for optoelectronic materials and devices. (normally offered alternate years)

228. Computational Materials
(3) CLARKE

Lecture, 3 hours.

Basic computational techniques and their application to simulating the behavior of materials. Techniques include: finite difference methods, Monte Carlo, molecular dynamics, cellular automata, and simulated annealing. (normally offered alternate years)

230. Elasticity and Plasticity
(3) MCMEEKING

Prerequisite: Materials 207 or ME 219

Same course as ME 230.

Review field equations of elasticity and plasticity. Energy principles and uniqueness theorems. Elementary problems in one and two dimensions, stress functions, and complex variable methods. Plastic stress-strain laws; flow potentials. Torsion and bending of plastic flow, slip line theory.

234. Fracture Mechanics
(3) STAFF

Prerequisites: Materials 207.

Same course as ME 275. Lecture, 3 hours.

Analytic solutions of a stationary crack under static loading. Elastic and elastoplastic analysis. The J integral. Energy balance and crack growth. Criteria for crack initiation and growth. Dynamic crack propagation. Fatigue. The micromechanics of fracture.

238A. Rheology of Polymeric Liquids
(3) STAFF

Same course as Chemical Engineering 238A.

An introduction to molecular and microscale theories for the viscoelastic behavior of complex fluids: suspensions, colloidal dispersions, liquid crystals, dilute polymer solutions.

238B. Rheology of Polymeric Liquids
(3) STAFF

Same course as Chemical Engineering 238B.

Continuation of Materials 238A: Emphasis of the second term is on concentrated systems and polymeric liquids, reptation theory and extensions of reptation theories to complex architectures in the linear viscoelastic regime. Nonlinear Rheology for polymers.

240. Finite Element Structural Analysis
(3) STAFF

Prerequisites: Materials 207 or equivalent.

Same course as ME 271. Lecture, 3 hours.

Definitions and basic element operations. Displacement approach in linear elasticity. Element formulation: direct methods and variational methods. Global analysis procedures: assemblage and solution. Plane stress and plane strain. Solids of revolution and general solids. Isoparametric representation and numerical integration. Computer implementation.

251A. Processing of Inorganic Materials
(3) LANGE

Prerequisite: consent of instructor.

Same course as Chemical Engineering 219A. Not open for credit to students who have completed Nuclear Engineering 219A. Lecture, 3 hours.

Fundamental concepts are presented for the synthesis of inorganic materials (zeolites, mesoporous materials, and epitaxial films) via chemical routes, and the processing of powders to form engineering shapes. The latter stresses fundamentals for manipulating the forces between particles that control rheological properties, particle packing and the plastic/elastic transition.

251B. Densification and Microstructural Control
(3) LANGE

Prerequisite: consent of instructor.

Same course as Chemical Engineering 219B. Lecture, 3 hours.

Mass transport and kinetic sintering theories. Thermodynamics of pore phase disappearance. Grain growth during densification. Effects of a liquid phase (liquid phase sintering). Effects of inert phases on densification. Effects of applied pressure. Control of grain growth after densification.

253. Liquid Crystal Materials
(4) SAFINYA

Prerequisite: consent of instructor. Lecture, 3 hours; laboratory, 2 hours.

Thermotropic and lyotropic liquid crystals (LC's). Classification and phase transitions. LC's in display technology. Laboratory experimentation using X-ray diffraction and polarized optical microscopy to characterize LC phases.

261. Composite Materials
(3) ZOK

Prerequisite: consent of instructor.

Same course as ME 265. Lecture, 3 hours.

Stress/strain relations in composites. Residual stresses. Fracture resistance of organic and inorganic matrix composites. Statistical aspects of fiber failure. Composite laminates and delamination cracks. Cumulative damage concepts. Interface properties. Design criteria. (normally offered alternate years)

262. Structural Ceramics
(3) STAFF

Prerequisite: consent of instructor.

Same course as Chemical Engineering 262. Lecture, 3 hours.

Ceramic processing methods. Flaws in ceramics. Fracture resistance and microstructure. Probabilistic design concepts. Non-destructive evaluation approaches. Reinforced ceramics. High temperature properties. Impact damage.

263. Thin Films and Multilayers
(3) EVANS

Lecture, 3 hours.

The development of stresses in thin films and its relaxation. Edge effects and discontinuities. Cracks in films and at interfaces. Delamination of residually stressed films. Buckling and buckle propagation of compressed films. Cyclic behavior and ratcheting effects.

265. Nanophase and Nanoparticulate Materials
(3) SESHADRI

Prerequisite: Materials 218 or equivalent. Lecture, 2.5 hours.

Course introduces graduate student to nanophase and nanoparticulate inorganic materials and their applications. Emphasis on how the properties of materials change when their size is diminished. The manner in which nanomaterials (particularly nanoparticulate materials) bridge the world of molecules with the world of solids is shown. Preparation, characterization and applications of nanomaterials is an integral part of the course.

267. Confined Electrons and Photons in Semiconductor Structures
(3) PETROFF

Prerequisites: Materials 162A-B or ECE 162A-B.

Same course as ECE 267. Lecture, 3 hours.

The properties of 1D, 2D and 3D confined electrons in semiconductors are reviewed. Properties of photons in microcavities and photonic crystals are introduced. Applications of photonic crystals to light extraction and modifications of the emitter properties are developed.

271A. Synthesis and Properties of Macromolecules
(3) STAFF

Prerequisite: consent of instructor.

Not open for credit to students who have completed Materials 273B. Lecture, 3 hours.

Basics of preparation of polymers and macromolecular assemblies, and characterization of large molecules and assemblies. Discussion of chemical structure, bonding, and reactivity.

271B. Structure and Characterization of Complex Fluids
(3) SAFINYA

Not open for credit to students who have completed Materials 280. Lecture, 3 hours.

Structure, phase behavior, and phase transitions in complex fluids. Characterization techniques including x-ray and neutron scattering, and light and microscopy methods. Systems include colloidal and surfactant dispersions (e.g., polyballs, microemulsions, and micelles), polymeric solutions and biomolecular materials (e.g., lyotropic liquid crystals).

271C. Properties of Macromolecules
(3) KRAMER

Not open for credit to students who have completed Materials 210. Lecture, 3 hours.

Fundamentals of the properties of macromolecular solutions, melts, and solids. Viscosity, diffusion and light scattering from dilute solutions. Elements of macromolecular solid state structure. Thermal properties and processes. Mechanical and transport properties. Introduction to electrical and optical properties of macromolecules.

273. Experiments in Macromolecular Materials
(3) STAFF

Not open for credit to students who have completed Materials 273C. Lecture, 3 hours; laboratory, 4 hours.

Experiments using X-ray and light scattering, optical and electron microscopy. Crystalline, quasi-crystalline, and amorphous materials. Solid, solution, and colloidal samples.

274. Solid State Inorganic Materials
(3) STAFF

Prerequisites: Chemistry 173A-B or equivalent.

Same course as Chemistry 274. Lecture, 3 hours.

An introductory course describing the synthesis, physical characterization, structure, electronic properties and uses of solid state materials.

276A. Biomolecular Materials I: Structure and Function
(3) SAFINYA

Prerequisite: consent of instructor. Lecture, 3 hours.

Survey of classes of biomolecules (lipids, carbohydrates, proteins, nucleic acids). Structure and function of molecular machines (enzymes for biosynthesis, motors, pumps).

276B. Biomolecular Materials II: Applications
(3) SAFINYA

Prerequisite: Physics 135 or Materials 276A. Lecture, 3 hours.

Interactions and self assembly in biomolecular materials. Chemical and drug delivery systems. Tissue engineering. Protein synthesis using recombinant nucleic acid methods: advanced materials development. Nonviral gene therapy. (normally offered alternate years)

277. Synthesis of Biomolecular Materials
(3) STAFF

Prerequisite: consent of instructor. Lecture, 3 hours.

Methods of preparation of biopolymers and biomolecular assemblies. Uses of biological techniques to engineer biomaterials. Uses of chemical techniques to prepare biological molecules as well as artificial biomimetic materials. Comparison of biological, chemical, and mixed synthesis for different applications. (normally offered alternate years)

278. Interactions in Biomolecular Complexes
(3) SAFINYA

Prerequisite: consent of instructor. Lecture, 3 hours.

Focuses on the interactions, structures, and functional properties of complexes comprised of supramolecular assemblies of biological molecules. Systems addressed include lipid membranes, lipid-DNA complexes, and assemblies of proteins of the cell cytoskeleton.

280. Defects in Semiconductors
(3) BAZAN

Introduction to the science and engineering of organic semiconductors. A connection is made between the two main classes of related materials: small molecules and conjugated polymers. Electronic structure is presented together with techniques for energy level measurements and the theory of charge carrier transport. Optical properties, including emission, energy transfer and electron transfer, are discussed within the context of optically amplified biosensors. Applications in field effect transistors, light emitting diodes and solar cells are reviewed. (F)

284. Synthetic Chemistry of

Macromolecules
(3) STAFF
Prerequisite: consent of instructor.
Same course as Chemistry 285. Lecture, 3 hours.
Molecular architecture and classification of macromolecules. Different methods for the preparation of polymers: free radical polymerization, ionicpolymerization, condensation polymerization and coordination polymerization. Bulk, solution, and emulsion polymerization. Principles of copolymerization, blockcopolymerization, grafting, network formation, chemical reactions on polymers.

286AA-ZZ. Special Topics in Inorganic Materials
(3) STAFF
Prerequisite: consent of instructor. Lecture, 3 hours.
This course will be offered on an irregular basis and will concern in-depth discussions of advanced topics in inorganic materials.

287AA-ZZ. Special Topics in Macromolecular Materials
(3) STAFF
Prerequisite: consent of instructor. Lecture, 3 hours.
This course will be offered on an irregular basis and will concern in-depth discussions of advanced topics in macromolecular materials.

288AA-ZZ. Special Topics in Electronic Materials.
(3) STAFF
Prerequisite: consent of instructor. Lecture, 3 hours.
This course will be offered on an irregular basis and will concern in-depth discussions of advanced topics in electronic materials.

289AA-ZZ. Special Topics in Structural Materials
(3) STAFF
Prerequisite: consent of instructor. Lecture, 3 hours.
This course will be offered on an irregular basis and will concern in-depth discussions of advanced topics in structural materials.

290. Research Group Studies
(1-3) STAFF
Prerequisite: consent of instructor. Seminar, 1-3 hours.
In this course students or instructors present recently published papers and/or results relevant to their own research.

501. Teaching Assistant Practicum
(1-4) STAFF
Prerequisite: consent of graduate advisor. This course is required for new teaching assistants.
No unit credit allowed toward advanced degree. Preparation, 1 hour; other, 2 hours.
Practical experience in the various activities associated with teaching including: lecturing, supervision of laboratories and discussion sections, preparation, and grading of homework and exams.

596. Directed Reading and Research
(2-4) STAFF
Tutorial, 1-3 hours.
Individual tutorial. Instructor usually student's major professor. A written proposal for each tutorial must be approved by the department chair.

598. Master's Thesis Research and Preparation
(1-12) STAFF
Prerequisite: consent of graduate advisor.
S/U grading only. Preparation, variable hours; tutorial, 1-3 hours.
For research underlying the thesis and writing of the thesis.

599. Ph.D. Dissertation Research and Preparation
(1-12) STAFF
Prerequisite: consent of chair of student's doctoral committee.
S/U grading only. Preparation, variable hours; tutorial, 1-3 hours.
Research and preparation of the dissertation.

Mechanical Engineering

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Chair: Kimberly Turner
Vice Chairs: Francesco Bullo and Jeffrey M. Moehlis

Faculty

Bassam Bamieh, Ph.D., Rice University, Professor (control systems design with applications to fluid flow problems)

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)

David Bothman, B.S., UC San Diego, Lecturer

Francesco Bullo, Ph.D., California Institute of Technology, Professor (motion planning and coordination, control systems, distributed and adaptive algorithms)

David R. Clarke, Ph.D., University of Cambridge, Professor (electrical ceramics, thermal barrier coatings, piezospectroscopy, mechanics of microelectronics) *3

Anthony G. Evans, Ph.D., Imperial College, London, Professor, Director of Center for Multifunctional Materials and Structures (thermostructural materials, ultralight structures, multifunctional materials and devices, actuating structures) *3

Frederic Gibou, Ph.D., University of California, Los Angeles, Associate Professor (computational science and engineering) *2

Gary S. Hansen, Ph.D., University of Michigan, Associate Professor (technology management program)

George Homsy, Ph.D., University of Illinois, Professor (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)

Mustafa Khammash, Ph.D., Rice University, Professor (robust analysis and synthesis of control systems and controls in biological systems)

Rouslan Krechetnikov, Ph.D., Moscow Institute of Physics & Technology, Assistant Professor (fluid mechanics, complex fluid interfaces, analytical mechanics, dynamical systems, stability theory, applied mathematics)

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

Glenn E. Lucas, Ph.D., Massachusetts Institute of Technology, Professor (mechanical properties of structural materials, environmental effects, structural reliability) *1

Eric F. Matthys, Ph.D., California Institute of Technology, Professor (heat transfer, fluid mechanics, rheology)

Robert M. McMeeking, Ph.D., Brown University, Professor (mechanics of materials, fracture mechanics, plasticity, computational mechanics) *3

Eckart Meiburg, Ph.D., University of Karlsruhe, 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)

Frederick Milstein, Ph.D., UC Los Angeles, Professor (mechanical properties of materials) *3

Jeffrey M. Moehlis, Ph.D., University of California, Berkeley, Associate Professor (nonlinear dynamics, fluid mechanics, biological dynamics, applied mathematics)

G. Robert Odette, Ph.D., Massachusetts Institute of Technology, Professor (deformation and fracture, high performance materials for use in severe environments) *3

Bradley E. Paden, Ph.D., UC Berkeley, Professor (control theory, kinematics, robotics)

Sumita Pennathur, Ph.D., Stanford University, Assistant Professor (application of microfabrication techniques and micro/nanoscale flow phenomena)

Linda R. Petzold, Ph.D., University of Illinois at Urbana–Champaign, Professor, Director of Computational Science and Engineering Graduate Emphasis (computational science and engineering; systems biology) *2

Hyongsok Tom Soh, Ph.D., Stanford University, Associate Professor (micro-electromechanical systems, integrated biosensors, multi-functional biomaterials)

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

Kimberly L. Turner, Ph.D., Cornell University, Professor (microelectromechanical systems, dynamics, solid mechanics, measurement and characterization of microsystems motion and device parameters)

Megan Valentine, Ph.D., Harvard University, Assistant Professor (single-molecule biophysics, cell mechanics, motor proteins, biomaterials)

Henry T. Yang, Ph.D., Cornell University, Professor (aerospace structures, structural dynamics and stability, transonic flutter and aeroelasticity, intelligent manufacturing systems)

Walter W. Yuen, Ph.D., UC Berkeley, Professor (thermal science, radiation heat transfer, heat transfer with phase change, combustion)

Emeriti Faculty

John C. Bruch, Jr., Ph.D., Stanford University, Professor Emeritus (applied mathematics, numerical solutions and analysis)

Roy S. Hickman, Ph.D., UC Berkeley, Professor Emeritus (fluid mechanics, physical gas dynamics, computer-aided design)

Frederick A. Leckie, Ph.D., Stanford University, Professor Emeritus (mechanics of materials, engineering design)

Wilbert J. Lick, Ph.D., Rensselaer Polytechnic Institute, Professor (oceanography and limnology, applied mathematics)

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 (fluid mechanics, physical oceanography, sediment transport)

Thomas P. Mitchell, Ph.D., California Institute of Technology, Professor Emeritus (theoretical and applied mechanics)

Marshall Tulin, M.S., Massachusetts Institute of Technology, Professor Emeritus, Ocean Engineering Laboratory Director (hydrodynamics, aerodynamics, turbulence, cavitation phenomena, drag reduction in turbulent flows)

James P. Vanyo, Ph.D., UC Los Angeles, Professor Emeritus (rotating nonrigid bodies, fluid dynamics)

*1 Joint appointment with the Department of Chemical Engineering.
*2 Joint appointment with the Department of Computer Science.
*3 Joint appointment with the Department of Materials.

Affiliated Faculty

Paul J. Atzberger (Mathematics)

Hector Ceniceros (Mathematics)

Patricia Holden (Bren School of Environmental Science and Management)

Arturo Keller (Bren School of Environmental Science and Management)

Gary Leal (Chemical Engineering)

Sally MacIntyre (Ecology, Evolution & Marine Biology)

The undergraduate program in mechanical engineering is accredited by the Engineering Accreditation Commission of ABET, 111 Market Place, Suite 1050, Baltimore, MD, 21202-4012 – telephone: (410) 347-7700. We offer a balanced curriculum of theory and application, involving: preparation in basic science, math, computing and writing; a comprehensive set of engineering science and laboratory courses; and a series of engineering design courses starting in the freshman year and concluding with a three course sequence in the senior year. Our students gain hands-on expertise with state-of-the art tools of computational design, analysis, and manufacturing that are increasingly used in industry, government, and academic institutions. In addition, the Department has a 15-unit elective program that allows students to gain depth in specific areas of interest, while maintaining appropriate breadth in the basic stem areas of the discipline. All students participate in a widely recognized design project program which includes projects sponsored by industry, UCSB researchers, as well as intercollegiate design competitions. The project program has been expanded to emphasize entrepreneurial product-oriented projects.

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:

- Successfully practice in either the traditional or the emerging technologies comprising mechanical engineering;
- Are successful in a range of engineering graduate programs including those in mechanical, environmental and materials engineering;
- Have a solid background in the fundamentals of engineering allowing them to pass the Fundamentals of Engineering examination;
- Are active 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.

Program Outcomes

Upon graduation, students in the mechanical engineering B.S. degree program:

1. Should possess a solid foundation in, and be able to apply the principles of, mathematics, science, and engineering to solve problems and have the ability to learn new skills relevant to his/her chosen career.
2. Have the ability to conduct and analyze data from experiments in dynamics, fluid dynamics, thermal science and materials, and should have been exposed to experimental design in at least one of these areas.
3. Should have experienced the use of current software in problem solving and design.
4. Should demonstrate the ability to design useful products, systems, and processes.
5. Should be able to work effectively on teams.
6. Should have an understanding of professional and ethical responsibilities.
7. Should be able to write lab reports and design reports and give effective oral presentations.
8. Should have the broad background in the humanities and the social sciences, which provides an awareness of contemporary issues and facilitates an understanding of the global and societal impact of engineering problems and solutions.
9. Should be a member of the American Society of Mechanical Engineers.

Undergraduate Program

Bachelor of Science—Mechanical Engineering

Note: Schedules should be planned to meet both General Education and major requirements. Detailed descriptions of these requirements are presented in the College of Engineering Announcement and General Education booklet. A minimum of 190 units is required for graduation.

Preparation for the major

All undergraduate majors in the department are required to meet a set of minimum unit and grade-point requirements and a set of General Education requirements which are common to all undergraduate majors in the College of Engineering. In addition, required preparation for the major consists of the following lower-division courses (or their equivalents if taken elsewhere): Engineering 3; Mechanical Engineering 6, 10, 14, 15, 16, 17; Chemistry 1A-B or 2A-B, 1AL-BL or 2AC-BC; Mathematics 3A-B-C, 5A-B-C; Physics 1, 2, 3, 4, and 3L, 4L.

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.

Upper-division major

The following 70 units are required: Materials 101; Mechanical Engineering 104, 105, 140A, 151A-B-C, 152A-B, 153, 154, 155A, 156A-B, 163, 189A-B-C, and 15 units of departmental electives.

The mechanical engineering elective courses allow 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 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) KHAMMASH, SOH

Prerequisites: Physics 3-3L; Mathematics 3C; open to ME majors only.

Not open for credit to students who have completed ECE 2A or 2B, or ECE 6A or 6B.

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

10. Engineering Graphics: Sketching, CAD, and Conceptual Design
(4) LAGUETTE

Prerequisite: ME majors only.

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) BOTHMAN, FIELDS, EVANS, BELTZ

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) STAFF

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) BOTHMAN

Prerequisite: ME majors only.

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) BELTZ, MILSTEIN, TURNER

Prerequisite: Physics 1 and Mathematics 3B; open to ME majors only.

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, MILSTEIN, KEDWARD, LAGUETTE

Prerequisites: ME 14; open to mechanical engineering majors only.

Hooke's law and properties of structural materials. Methods of sections and virtual work and energy methods. Design applications to engineering structures, problems of tension, torsion, flexure and combined loading. Design beyond the elastic limit.

16. Engineering Mechanics: Dynamics
(4) TURNER, BAMIEH

Prerequisites: Physics 2; ME 14; and, Mathematics 5C; (may be taken concurrently); open to ME majors only.

Not open for credit to students who have completed ME 163A.

Vectorial kinematics of particles in space, orthogonal coordination systems. Relative and constrained motions of particles. Dynamics of particles and systems of particles, equations of motion, energy and momentum methods. Collisions. Planar kinematics and kinetics of rigid bodies. Energy and momentum methods for analyzing rigid body systems. Moving frames and relative motion.

17. Mathematics of Engineering
(3) MOEHLIS, HOMSY, GIBOU

Prerequisite: Engineering 3; Mathematics 5B (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 matrix algebra, 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 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 maximum of 6 units, variable hours.

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.

104. Sensors, Actuators and Computer Interfacing
(3) BAMIEH, PADEN

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) BENNETT, MATTHYS, VALENTINE

Prerequisite: ME 151B, 152B, 163; and, 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)

106A. Advanced Mechanical Engineering Laboratory
(3) KHAMMASH, BAMIEH

Prerequisite: ME 155A.

An advanced lab course with experiments in dynamical systems and feedback control design. Students design, troubleshoot, and perform detailed, multi-session experiments.

106B. Mechanics, Materials and Structures Laboratory
(3) ZOK, EVANS

Prerequisites: ME 15; ME 154; ME 156A; and Materials 100B or 101.

Experiments on mechanical behavior of materials and structures. Assessment of analytical and finite element methods for mechanical design, with applications to optimization of lightweight structures.

106C. Advanced Thermo/Fluids Laboratory
(3) BENNETT

Prerequisite: ME 105 and 151A-B, ME 151C (may be concurrent) and ME 152A-B

Perform thermo/fluid experiments that emphasize elements of thermodynamics, heat transfer, and fluid mechanics. This laboratory course stresses critical thinking skills required to construct and perform experiments independently, and to investigate physical phenomena experimentally.

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 Conversion
(3) MATTHYS

Prerequisite: ME 151C and 152; or, Chemical Engineering 110B and 120A.

Overview of energy usage and production from prehistory to present times (technical, environmental, and societal issues). Technical analysis of the modern means of energy production (fossil, nuclear, hydro, wind, solar, geothermal, biomass, etc.): operating principles, hardware, engineering issues, environmental impact, etc.

114. Water Supply and Pollution Control
(3) STAFF

Prerequisite: ME 152A or Chemical Engineering 120A.

Water supply and quality requirements for domestic, industrial, agricultural, and recreational uses. Properties of natural surface and groundwaters. Pollutants in surface and groundwaters. Transport and fates of waterborne pollutants. Water and sewage treatment processes. Waste water reclamation. Water quality management in ground and surface water environments.

119. Introduction to Coastal Engineering
(3) STAFF

Prerequisite: ME 152A.

Quantitative description of waves and tides: refraction, shoaling. Nearshore circulation. Sediment characteristics and transport; equilibrium beach profile; shoreline protection.

124. Advanced Topics in Transport Phenomena/Safety
(3) THEOFANOUS

Prerequisites: Chemical Engineering 120A-B-C, or ME 151A-B and ME 152A.

Same course as Chemical Engineering 124.

Hazard identification and assessments, runaway reactions, emergency relief. Plant accidents and safety issues. Dispersion and consequences of releases.

125AA-ZZ. 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, cad/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) LAGUETTE

Prerequisite: Mechanical Engineering 10, 14, 15, 16, and 153; open to ME majors only.

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, YUEN, HOMSY

Prerequisite: ME 151C.

This 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.

136. Introduction to Multiphase Flows
(3) THEOFANOUS
Prerequisites: Chemical Engineering 120A-B-C; or, ME 151C and 152A.
Same course as Chemical Engineering 136.
Development from basic concepts and techniques of fluid mechanics and heat transfer, to local behavior in multiphase flows. Key multiphase phenomena, related physics. Extension of local conservation principles to usable formulations in multiphase flows. Modelling approaches. Practical examples.

138. Risk Assessment and Management
(3) THEOFANOUS
Prerequisites: ME 151B and 152A, or Chemical Engineering 120A-B-C.
Same course as Chemical Engineering 138.
Conceptual foundations of risk and its utility for decision making. Determinism, statistical inference, and uncertainty. Formulation of safety goals and approaches to risk management. Generalized methodology and tools for assessing risks in the industrial, ecological, and public health context.

140A. Numerical Analysis in Engineering
(3) HOMSY, MOEHLIS, GIBOU, MEIBURG
Prerequisites: ME 17 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; open to ME and Chemical Engineering majors only.
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 MicroElectroMechanical Systems (MEMS)
(3) TURNER, PENNATHUR
Prerequisites: ME 104 and 163; or, ECE 130A and 137A; with a minimum grade of C- in both.
Same course as ECE 141A.
Analysis of MEMS actuators and displacement sensors with emphasis on the analysis of capacitor-based sensing and actuation. Analysis and design of operational-amplifier models and circuits for capacitor sensors including feedback concepts. Vibration analysis of MEMS structures including wave equations for 'string' and bar structures. MEMS scaling concepts.

141B. MEMS: Semiconductor Processing and Device Characterization with Laboratory
(4) TURNER, PENNATHUR
Prerequisites: ME 141A or ECE 141A; and, Chemistry 1B-BL.
Same course as ECE 141B.
Lectures and laboratory on semiconductor processing for MEMS. Description and analysis of key semiconductor and equipment used for MEMS. Design and fabrication of MEMS capacitor-actuator and accelerometers, includes a description of MEMS characterization tools.

141C. Introduction to Microfluidics and BioMEMS
(3) MEINHART
Prerequisite: ME 141A or ECE 141A; open to ME and EE majors only.
Same course as ECE 141C.
Introduces physical phenomena associated with microscale/nanoscale fluid mechanics, microfluids, and bioMEMS. Analytical methods and numerical simulation tools are used for analysis of microfluids.

151A. Thermosciences 1
(4) MATTHYS
Prerequisite: Physics 2; ME 14; and, Mathematics 5C.
Basic concepts in thermodynamics, system analysis, energy, thermodynamic laws, and cycles. (F)

151B. Thermosciences 2
(4) MATTHYS
Prerequisite: 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
(3) HOMSY, MATTHYS
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) HOMSY, MATTHYS, MEINHART
Prerequisite: Mathematics 5C and ME 16.
Introduction to the fundamental concepts in fluid mechanics and basic fluid properties. Basic equations of fluid flow. Dimensional analysis and similitude. Hydrodynamics. (F)

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

153. Introduction to Mechanical Engineering Design
(3) BELTZ, TURNER, KEDWARD, LAGUETTE
Prerequisites: ME 10 and 16; open to ME majors only.
Design methods. Creative thinking. Introduction to manufacturing processes, design for manufacturing. Project planning and teamwork. Applications of engineering software. Application of engineering principles to practical problem solving. Codes and standards. Engineering ethics.

154. Design and Analysis of Structures
(3) MCMEEKING, KEDWARD, SHUGAR
Prerequisites: ME 15 and 16; 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) BAMIEH, ASTROM, BULLO
Prerequisite: ME 17; ME 140A (may be taken concurrently); 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) PADEN
Prerequisite: ME 155A.
Dynamic system modeling using state-space methods, controllability and observability, state-space methods for control design including pole placement, and linear quadratic regulator methods. Observers and observer-based feedback controllers. Sampled-data and digital control. Laboratory exercises using MATLAB for simulation and control design.

156A. Mechanical Engineering Design - I
(3) TURNER, LUCAS, EVANS
Prerequisite: ME 151C (may be concurrent), 152B, 153 and 154; and MATRL 101 or 100B; 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) KEDWARD
Prerequisites: ME 156A; open to ME majors only.
Machine elements including gears, bearings, and shafts. Joint design and analysis: bolts, rivets, adhesive bonding and welding. Machine dynamics and fatigue. Design for reliability and safety. Codes and standards. Topics covered are applied in practical design projects.

158. Computer Aided Design and Manufacturing
(3) BOTHMAN
Prerequisites: ME 10 and 156A; open to ME majors only.
Engineering applications using advanced 3-D CAD software for plastic part designs and tooling. Topics include an overview of the design for injection molded plastic parts, material selections and electronic tooling design via CAD and CNC system software. Emphasis is put into final design projects that are designed to be functional, manufacturable, and esthetically pleasing.

162. Introduction to Elasticity
(3) MCMEEKING, BELTZ
Prerequisites: ME 15 and 140A.
Equations of equilibrium, compatibility, and boundary conditions. Solutionsof two-dimensional problems in rectangular and polar coordinates. Eigen-solutions for the Wedge and Williams' solution for cracks. Stress intensity factors. Extension, torsion, and bending. Energy theorems. Introduction to wave propagation in elastic solids.

163. Engineering Mechanics: Vibrations
(3) MEZIC, BULLO
Prerequisites: ME 16; open to ME majors only.
Not open for credit to students who have completed ME 163B.
Topics relating to vibration in mechanical systems; exact and approximate methods of analysis, matrix methods, generalized coordinates and Lagrange's equations, applications to systems. Basic feedback systems and controlled dynamic behavior.

166. Advanced Strength of Materials
(3) TURNER, KEDWARD
Prerequisite: ME 15.
Analysis of statically determinate and indeterminate systems using integration, area moment, and energy methods. Beams on elastic foundations, curved beams, stress concentrations, fatigue, and theories of failure for ductile and brittle materials. Photoelasticity and other experimental techniques are covered, as well as methods of interpreting in-service failures.

167. Structural Analysis
(3) YANG
Prerequisites: ME 15 or 165; and ME 140A.
Presents introductory matrix methods for analysis of structures. Topics include review of matrix algebra and linear equations, basic structural theorems including the principle of superposition and energy theorems, truss bar, beam and plane frame elements, and programming techniques to realize these concepts.

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

170A. Introduction to Robotics: Robot Mechanics
(4) PADEN, BULLO
Same course as ECE 181A.
Recommended preparation: ME 16.
Overview of robot kinematics and dynamics. Structure and operation of industrial robots. Robot performance: workspace, velocity, precision, payload. Comparative discussion of robot mechanical designs. Actuators. Robot coordinate systems. Kinematics of position. Dynamics of manipulators.

170C. Introduction to Robotics: Robot Control

(4) PADEN

Prerequisites: ECE 2A-B-C with a minimum grade of C-; or ME 104.

Same course as ECE 181C.

Overview of robot control technology from open-loop manipulators and sensing systems, to single-joint servovalves and servomotors, to integrated adaptive force and position control using feedback from machine vision and touch sensing systems. Design emphasis on accurate tracking accomplished with minimal algorithm complexity.

173. Control Systems Synthesis
(3) BAMIEH

Prerequisite: ME 155A.

Not open for credit to students who have completed ECE 147A.

Pole-placement, observer design, observer-based compensation, frequency and time-domain techniques, internal model principle, linear quadratic regulators, modeling uncertainty in signals and systems, robust stability and performance, synthesis for robustness.

185. Materials in Engineering
(3) LEVI, ODETTE

Prerequisite: Materials 100B or 101.

Same course as Materials 185.

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.

186. Manufacturing and Materials
(3) LEVI, ODETTE

Prerequisites: ME 15 and 151C; and, Materials 100B or 101.

Same course as Materials 186.

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.

189A-B-C. Capstone Mechanical Engineering Design Project
(2-2-2) LAGUETTE

Prerequisites: ME 153; and ME 156A (may be taken concurrently).

A three-quarter sequence with grades issued for each quarter. Students may not concurrently enroll in ME 197 and ME 189A-B-C with the same design project.

Students work in teams under the direction of a faculty advisor to tackle an engineering design project. Engineering communication, such as reports and oral presentations are covered. Course emphasizes practical, hands-on experience, and integrates analytical and design skills acquired in the companion ME 156 courses.

193. Internship in Industry
(1) STAFF

Prerequisite: consent of instructor and prior departmental approval needed.

Cannot be used as a departmental elective. May be repeated to a maximum of 2 units.

Students obtain credit for a mechanical engineering related internship and/or industrial experience under faculty supervision. A 6-10 page written report is required for credit.

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.

Special projects in design engineering. Course offers motivated students opportunity to synthesize academic skills by designing and building new machines.

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

200. Professional Seminar
(1) MCMEEKING, MILSTEIN, ODETTE

Prerequisite: graduate standing.

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

200P. Master of Science Project
(3) STAFF

Prerequisite: graduate standing.

A ten-week research project on an advanced topic in Mechanical Engineering.

201. Advanced Dynamics
(3) MEZIC

Newton's laws and symmetries, Newton, Laplace and principle of determinism, qualitative analysis of Newton's equations of motion, Hamiltonian mechanics, one degree of freedom (DOF) systems, two DOF systems, motion in central fields, application to molecular dynamics, control of classical dynamical systems, Lagrangian mechanics, chaos and ergodic theory, rigid body motion.

202. Advanced Dynamics
(3) MEZIC

Prerequisite: ME 201; graduate standing.

Differentiable manifolds in dynamical systems theory, differential forms, Hamiltonian phase flow, Lie algebras of vector fields, canonical formalism, integrable systems, introduction to perturbation theory, averaging, chaos in Hamiltonian systems, theory of invariant measures in dynamical systems, ergodic partition, dissipative dynamical systems, limit cycles, Lyapunov exponents, strange attractors.

203. Special Topics in Dynamical Systems
(3) MEZIC

Prerequisite: ME 201.

Geometric mechanics, volume-preserving dynamical systems, molecular dynamics; Infinite dimensional dynamics and finite dimensional approximations including incompressible Euler equations and point vortex theory, transport and fluid mixing, control of measure-preserving systems, equilibrium and non-equilibrium statistical mechanics methods for vortex gases.

207. Faculty Research Seminar
(1) STAFF

A series of bi-weekly presentations given by ladder faculty members to familiarize graduate students with current department research projects. This course is required to be taken by all graduate students within the first year of arrival.

210A. Matrix Analysis and Computation
(4) STAFF

Prerequisite: consent of instructor.

Same course as Computer Science 211A, ECE 210A, Mathematics 206A, Chemical Engineering 211A, and Geology 251A. Students should be proficient in basic numerical methods, linear algebra, mathematically rigorous proofs, and some programming language.

Graduate level-matrix theory with introduction to matrix computations. SVD's, pseudoinverses, variational characterization of eigenvalues, perturbation theory, direct and iterative methods for matrix computations.

210B. Numerical Simulation
(4) PETZOLD

Prerequisite: consent of instructor.

Same course as Computer Science 211B, ECE 210B, Mathematics 206B, and Chemical Engineering 211B and Geology 251B. Students should be proficient in basic numerical methods, linear algebra, mathematically rigorous proofs, and some programming language.

Linear multistep methods and Runge-Kutta methods for ordinary differential equations: stability, order and convergence. Stiffness. Differential algebraic equations. Numerical solution of boundary value problems.

210C. Numerical Solution of Partial Differential Equations—Finite Difference Methods
(4) STAFF

Prerequisite: consent of instructor.

Same course as Computer Science 211C, ECE 210C, Mathematics 206C, Chemical Engineering 211C, and Geolgy 251C. Students should be proficient in basic numerical methods, linear algebra, mathematically rigorous proofs, and some programming language.

Finite difference methods for hyperbolic, parabolic and elliptic PDEs, with application to problems in science and engineering. Convergence, consistency, order and stability of finite difference methods. Dissipation and dispersion. Finite volume methods. Software design and adaptivity.

210D. Numerical Solution of Partial Differential Equations—Finite Element Methods
(4) STAFF

Prerequisite: consent of instructor.

Same course as Computer Science 211D, ECE 210D, Mathematics 206D, Chemical Engineering 211D, and Geology 251D. Students should be proficient in basic numerical methods, linear algebra, mathematically rigorous proofs, and some programming language.

Weighted residual and finite element methods for the solution of hyperbolic, parabolic and elliptical partial differential equations, with application to problems in science and engineering. Error estimates. Standard and discontinuous Galerkin methods.

212. Risk Assessment and Management
(3) THEOFANOUS

Prerequisites: consent of instructor.

Same course as Chemical Engineering 212

Conceptual foundations of risk and its utility for decision making. Determinism, statistical inference, and uncertainty. Formulation of safety goals and approaches to risk management. Generalized methodology and tools for assessing risks in the industrial, ecological, and public health context.

215A. Applied Dynamical Systems I
(3) MOEHLIS

Prerequisite: graduate standing.

Phase-plane methods, non-linear oscillators, stability of fixed pints and periodic orbits, invariant manifolds, structural stability, normal form theory, local bifurcations for vector fields and maps, applications from engineering, physics, chemistry, and biology.

215B. Applied Dynamical Systems II
(3) MOEHLIS

Prerequisites: ME 215A; graduate standing.

Local codimension two bifurcations, global bifurcations, chaos for vector fields and maps, Smale horseshoe, symbolic dynamics, strange attractors, universality, bifyrcation with symmetry, perturbation theory and averaging, Melnikov's methods, canards, applications from engineering, physics, chemistry, and biology.

216. Level Set Methods
(4) GIBOU

Prerequisite: Computer Science 211C, or Chemical Engineering 211C, or ECE 210C, or ME 210C.

Same course as Chemical Engineering 226, ECE 226, and Computer Science 216.

Mathematical description of the level set method and design of the numerical methods used in its implementations (ENO-WENO, Godunov, Lax-Friedrich, etc.). Introduction to the Ghost Fluid Method. Applications in CFD, Materials Sciences, Computer Vision and Computer Graphics.

218. Introduction to Multiphase Flows
(3) THEOFANOUS

Prerequisite: consent of instructor.

Same course as Chemical Engineering 218.

Development from basic concepts and techniques of fluid mechanics and heat transfer, to local behavior in multiphase flows. Key multiphase phenomena, related physics. Extension of local conservation principles to usable formulations in multiphase flows. Modelling approaches. Practical examples. Computer simulations.

219. Mechanics of Materials
(3) MCMEEKING, BELTZ

Same course as Materials 207.

Matrices and tensors, stress deformation and flow, compatibility conditions, constitutive equations, field equations and boundary conditions in fluids and solids, applications in solid and fluid mechanics.

220A-B. Fundamentals of Fluid Mechanics
(3-3) BENNETT, HOMSY, MEINHART

Prerequisites: ME 151A-B and 152A-B.

Introductory course in fluid mechanics. Basic equations of motion (continuity, momentum, energy, vorticity), coordinate transformations, "potential" flow, thin airfoil theory, conformal mapping, vortex dynamics, boundary layers, stability theory, laminar/turbulent transition, turbulence. Inviscid/viscid, irrotational/rotational, incompressible/compressible flow examples.

221. Advanced Viscous Flow
(3) HOMSY

Prerequisite: ME 220A.

Review the Navier-Stokes equations in velocity, pressure, and vorticity variables. Analyze details of important low and moderate Reynolds number flow applications and then high Reynolds number flows with boundary layer phenomena. Compare exact, approximate, numerical, and experimental solution methods.

223. Turbulent Flow
(3) STAFF

Prerequisites: ME 220A-B or Chemical Engineering 220A-B.

Same course as Chemical Engineering 221.

Nature and origin of turbulence, boundary layer mechanics law of the wall, wakes, and jets, transport of properties, statistical description of turbulence, measurement problems, stratification effects. Application of principles to practical problems is stressed.

225AA-ZZ. Special Topics in Mechanical Engineering
(3) STAFF

Prerequisite: consent of instructor.

Specialized courses dealing with advanced topics and recent developments in one or more of the following areas: dynamic systems, control and robotics, fluid mechanics, materials science and engineering, ocean engineering, solid mechanics and structures, thermal sciences.

230. Elasticity and Plasticity
(3) MCMEEKING, BELTZ

Prerequisite: ME 219 or MATRL 207

Same course as Materials 230.

Review field equations of elasticity and plasticity. Energy principles and uniqueness theorems. Elementary problems in one and two dimensions, stress functions, and complex variable methods. Plastic stress-strain laws; flow potentials. Torsion and bending of plastic flow, slip line theory.

233A. Design of Composite Structures
(3) KEDWARD

Prerequisite: ME 230 or 275A.

Emphasis is placed on the differences of design with composites vis-à-vis the design of conventional metallic structures. The content is directed at the class of polymer-matrix composites.

234A. Structural Dynamics
(3) STAFF

Formulation of the equations of motion for free and forced response of single and multi-degree of freedom systems and for distributed-parameter systems. Modal analysis. Approximate solution techniques. Numerical algorithms. Damping.

236. Nonlinear Control Systems
(4) KOKOTOVIC, TEEL

Same course as ECE 236.

Recommended preparation: ECE 230A.

Analysis and design of nonlinear control systems. Focus on Lyapunov stability theory, with sufficient time devoted to contrasts between linear and nonlinear systems, input-output stability and the describing function method.

237. Nonlinear Control Design
(4) KOKOTOVIC

Prerequisite: ECE 236 or ME 236.

Same course as ECE 237.

Stabilizability by linearization and by geometric methods. State feedback design and input/output linearization. Observability and output feedback design. Singular perturbations and composite control. Backstepping design of robust controllers for systems with uncertain nonlinearities. Adaptive nonlinear control.

239. Conduction Heat Transfer
(3) STAFF

Prerequisite: undergraduate course in heat transfer.

Development of mathematical representation of conduction heat transfer and techniques available for analytical, analog, and numerical solutions.

240. Convective Heat Transfer
(3) STAFF

Prerequisite: undergraduate course in heat transfer.

Solutions to the momentum, continuity, and energy equations will be considered for both natural and forced convection. Applications to industrial problems, convective transfer in high-speed flows, heat transfer in rarefied flows, and the effects of chemical reactions on convective rates will be included.

241. Radiative Energy Transfer
(3) STAFF

Prerequisite: undergraduate course in heat transfer.

The physical nature of radiation and of its interaction with matter, conservation principles in radiative transfer and their relation to molecular and convective processes, and thermodynamic equilibrium with consideration of nondimensional parameters is considered. Applications to astrophysics, combustion, and plasma technology are discussed.

243A-B. Linear Systems I, II
(4-4) KOKOTOVIC, BAMIEH

Prerequisites: ME 210A (for 243A): ECE 140; and, ECE 230A or ME 243A; and ME 210A.

Same courses as ECE 230A-B.

Internal and external descriptions. Solution of state equations. Controllability and observability realizations. Pole assignment, observers; modern compensator design. Disturbance localization and decoupling. Least-squares control. Least-squares estimation; Kalman filters; smoothing. The separation theorem; LQG compensator design. Computational considerations. Selected additional topics.

244A. Advanced Theoretical Methods in Engineering
(4) FREDRICKSON, CHMELKA, LEAL

Prerequisite: consent of instructor.

Same course as Chemical Engineering 230A.

Methods of solution of partial differential equations and boundary value problems. Linear vector and function spaces, generalized Fourier analysis, Sturm-Liouville theory, calculus of variations, and conformal mapping techniques.

244B. Advanced Theoretical Methods in Engineering
(3) FREDRICKSON

Prerequisites: ME 244A and consent of instructor.

Same course as Chemical Engineering 230B.

Advanced mathematical methods for engineers and scientists. Complex analysis, integral equations and Green's functions. Asymptotic analysis of integrals and sums. Boundary layer methods and WKB theory.

250. Advanced Thermodynamics
(3) MILSTEIN

Prerequisites: ME 151A-B.

An extended treatment of the fundamentals of classical thermodynamics, including availability and reversibility, the chemical potential, properties of matter, thermochemistry, chemical equilibrium of real gases and gas mixtures.

251. Statistical Thermodynamics
(3) MILSTEIN

Prerequisites: ME 151A-B.

An extended treatment of the fundamentals of statistical thermodynamics, equilibrium distributions, properties of gases, liquids, and solids.

252A. Computational Fluid Dynamics
(3) MEIBURG

Prerequisites: ME 210C or Computer Science 211C or ECE 210C or Mathematics 206C or Chemical Engineering 211C.

Numerical simulation of fluid flows. Basic discretization techniques for parabolic, elliptical, and hyperbolic conservation laws. Stability and accuracy. Diffusion equation, linear convection equation.

252B. Computational Fluid Dynamics
(3) MEIBURG

Prerequisites: ME 210C or Computer Science 211C or ECE 210C or Mathematics 206C or Chemical Engineering 211C.

Discussion of appropriate boundary conditions. Nonlinear convection dominated problems, curvilinear coordinates, basics of grid generation. Inviscid flow, boundary layer flow, incompressible Navier-Stokes flows.

252C. Computational Fluid Dynamics
(3) MEIBURG

Prerequisites: ME 210C or Computer Science 211C or ECE 210C or Mathematics 206C or Chemical Engineering 211C.

Compressible inviscid flows. Compressible viscous flows. Boundary element methods. Lagrangian and vortex methods.

254. Optimal Control of Dynamic Systems
(4) BAMIEH

Prerequisite: ME 243A or ECE 230A or equivalent.

Calculus of variations and Gateaux and Frechet derivatives. Optimization in dynamic systems and Pontryagin's principle. Invariant Imbedding and deterministic and stochastic Dynamic Programming. Numerical solutions of optimal control problems. Min-max problems and differential games. Extensive treatment of Linear Quadratic Problems.

256. Introductory Robust Control with Applications
(4) SMITH, KHAMMASH

Prerequisites: ECE 230A or ME 255A; and ECE 230B or ME 243B (may be taken concurrently).

Same course as ECE 232.

Robust Control theory; uncertainty modeling; stability of systems in the presence of norm-bounded perturbations; induced norm performance problems; structured singular value analysis; H-infinity control theory; model reduction; computer simulation based design project involving practical problems.

260A. Materials Structures and Bonding
(3) MILSTEIN

Prerequisite: consent of instructor.

Crystal structures (Miller indices, Bravais lattices, symmetry operations). Modeling of atomic bonding, determination and applications of interatomic potentials, atomic basis for elastic moduli. Crystal anisotrophy. Lattice statics and molecular dynamics computations.

262. Thermodynamics and Phase Equilibria
(3) ODETTE, CLARKE, ZOK

Prerequisite: consent of instructor.

Same course as Materials 201.

Advanced thermodynamics with emphasis on phase equilibria, properties of solutions, and multicomponent systems.

264. Mechanical Behavior of Materials
(3) STAFF

Prerequisite: consent of instructor.

Same course as Materials 220.

Concepts of stress and strain. Deformation of metals, polymers, and ceramics. Elasticity, viscoelasticity, plastic flow, and creep. Linear elastic fracture mechanics. Mechanisms of ductile and brittle fracture.

265. Composite Materials
(3) ODETTE, CLARKE, ZOK

Prerequisite: consent of instructor.

Same course as Materials 261.

Stress and strain relations in composites. Residual stresses. The fracture resistance of organic and inorganic matrix composites. Statistical aspects of fiber failure. Composite laminates and delamination cracks. Cumulative damage concepts. Interface properties. Design criteria.

271. Finite Element Structural Analysis
(3) MCMEEKING

Prerequisite: ME 219.

Same course as Materials 240.

Definitions and basic element operations. Displacement approach in linear elasticity. Element formulation: direct methods and variational methods. Global analysis procedures: assemblage and solution. Plane stress and plane strain. Solids of revolution and general solids. Isoparametric representation and numerical integration. Computer implementation.

275. Fracture Mechanics
(3) ODETTE, MCMEEKING

Prerequisite: ME 219.

Same course as Materials 234.

Analytic solutions of a stationary crack under static loading. Elastic and elastoplastic analysis. The J integral. Energy balance and crack growth. Criteria for crack initiation and growth. Dynamic crack progagation. Fatigue. The micromechanics of fracture.

285. Geophysical Fluid Dynamics
(3) MCLEAN

Prerequisite: ME 152A.

The ocean-atmosphere system. Air-sea interaction. Governing equations for rotating system: conservation of mass, momentum and energy. Ocean surface waves: generation, spectral characteristics. Internal waves. Geostrophic motion. Rotating boundary layers: Ekman dynamics. Tides. Kelvin waves.

291A. Physics of Transducers
(3) SOH

Prerequisite: graduate standing.

Recommended preparation: ECE 220A (may be taken concurrently).

The use of concepts in electromagnetic theory and solid state physics to describe capacitive, pierzoresistive, piezoelectric and tunneling transduction mechanisms and analyze their applications in microsystems technology.

292. Design of Transducers
(3) TURNER, PENNATHUR

Prerequisites: ME 291A and ECE 220A; graduate standing.

Design issues associated with microscale transduction. Electrodynamics, linear and nonlinear mechanical behavior, sensing methods, MEMS-specific fabrication design rules, and layout are all covered. Modeling techniques for electromechanical systems are also discussed.

295. Group Studies: Controls, Dynamical Systems, and Computation
(1) STAFF

Same course as ECE 295, Computer Science 592, and Chemical Engineering 295.

A series of weekly lectures given by university staff and outside experts in the fields of control systems, dynamical systems, and computation.

501. Teaching Assistant Practicum
(1-4) STAFF

Normally required of students serving as teaching assistants. No unit credit allowed towards advanced degree.

Practical experience in the various activities associated with teaching, including lecturing, supervision of laboratories and discussion sections, preparation and grading of homework and exams.

503. Research Assistant Practicum
(1-4) STAFF

Will not count as unit credit towards M.S. or Ph.D. degree in mechanical engineering.

Practical experience in the various activities associated with research, including experimental work, theoretical work and analyses, and assisting department faculty and other professional researchers in their duties.

596. Directed Research
(1-12) STAFF

Prerequisite: consent of instructor.

Not applicable to course requirement for M.S. and Ph.D. degree. S/U grading.

Experimental or theoretical research undertaken under the direction of a faculty member for graduate students who have not yet advanced to candidacy.

597. Individual Study for Ph.D. Qualifying Examination
(1-12) STAFF

Prerequisite: graduate standing.

No unit credit allowed toward advanced degree. Maximum of 12 units per quarter; enrollment limited to 24 units per examination. Instructor is normally student's major advisor. S/U grading.

Individual studies for Ph.D. qualifying examination.

598. Master's Thesis Research and Preparation
(1-12) STAFF

Prerequisite: consent of thesis advisor.

No unit credit allowed toward advanced degree.

For research underlying the thesis and writing of the thesis.

599. Ph.D. Dissertation Research and Preparation
(1-12) STAFF

Prerequisite: consent of dissertation advisor.

No unit credit allowed toward advanced degree.

For research and preparation of the dissertation.

CHEMICAL ENGINEERING

PREPARATION FOR THE MAJOR	Units 80
CH E 1A	1
CH E 10	3
CHEM 1A, 1B, 1C or 2A, 2B, 2C	9
CHEM 1AL, 1BL, 1CL or 2AC, 2BC, 2CC	6
CHEM 6AL-BL	6
CHEM 109A-B-C	12
ENGR 3	3
MATH 3A-B-C, 5A-B-C	24
PHYS 1, 2, 3, 3L, 4, 4L	16

UPPER DIVISION MAJOR	78
CH E 110A-B	6
CH E 119	1
CH E 120A-B-C	10
CH E 128	3
CH E 132A-B-C	10
CH E 140A-B	6
CH E 152A	4
CH E 170	3
CH E 180A-B	6
CH E 184A-B	6
CHEM 113B-C	8
MATRL 101 or MATRL 100B *	3

* see note on next page

Technical Elective requirement 12

Prior approval of the student's technical electives must be obtained from the student's faculty adviser.

Approved Technical Elective Requirement classes:

CH E 102	CHEM 145	MCDB 126A-B-C
CH E 121	CHEM 147	MCDB 133
CH E 124	CHEM 150	MCDB 138
CH E 125	ECE 130A-B-C	ME 110
CH E 136	ECE 183	ME 112
CH E 138	ENGR 101	ME 114
CH E 141	ENGR 103	ME 119
CH E 152B	ENGR 185A-B-C-D	ME 128
CH E 154	MATH 122A-B	ME 134
CH E 160	MATRL 100A,C	ME 169
CH E 171	MATRL 160	ME 185
CH E 198	MATRL 185	PHYS 123A-B
CHEM 123	MCDB 101A-B	PHYS 127AL
CHEM 126	MCDB 111	PHYS 127BL
CHEM 142A-B-C		

Technical electives taken:

______________________ | ______________________

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

UNIVERSITY REQUIREMENTS

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

____

UC Entry Level Requirement: English Composition

Must be fulfilled within three quarters of matriculation

Satisfied by:______________________________

GENERAL EDUCATION

General Subject Areas

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

A-1: ______________________ **A-2**: ______________________

Areas D & E: Social Sciences, Culture and Thought (2 courses minimum)

______________________ ______________________

Areas F & G: The Arts, Literature (2 courses minimum, at least 1 from Area G)

______________________ G______________________

2 additional courses from Areas D, E, F, or G

______________________ ______________________

Special Subject Areas

(Please refer to the General Education Program Requirements booklet for more information)

Depth:

______________________ ______________________

______________________ ______________________

Ethnicity (1 course):______________________

European Traditions (1 course):______________________

Writing (4 courses required):

______________________ ______________________

______________________ ______________________

NON-MAJOR ELECTIVES 36

General Education and Free Electives taken:

TOTAL UNITS REQUIRED FOR GRADUATION 194

CHEMICAL ENGINEERING

FRESHMAN YEAR

FALL	units	WINTER	units	SPRING	units
CH E 1A	1	CHEM 1B or 2B	3	CHEM 1C or 2C	3
CHEM 1A or 2A	3	CHEM 1BL or 2BC	2	CHEM 1CL or 2CC	2
CHEM 1AL or 2AC	2	MATH 3B	4	MATH 3C	4
ENGR 3 or G.E. elective	3	PHYS 1	4	PHYS 2	4
MATH 3A	4	WRIT 2E or 50E	4	WRIT 50E or G.E. elective or ENGR 3	4
WRIT 1E or 2E	4				
TOTAL	**17**		**17**		**17**

SOPHOMORE YEAR

FALL	units	WINTER	units	SPRING	units
CH E 10	3	CH E 110A	3	CH E 110B	3
CHEM 109A	4	CHEM 6AL	3	CH E 132A	4
MATH 5A	4	CHEM 109B	4	CHEM 6BL	3
PHYS 3	3	MATH 5B	4	CHEM 109C	4
PHYS 3L	1	PHYS 4	3	MATH 5C	4
		PHYS 4L	1		
TOTAL	**15**		**18**		**18**

JUNIOR YEAR

FALL	units	WINTER	units	SPRING	units
CH E 119	1	CH E 120B	3	CH E 120C	3
CH E 120A	4	CH E 132C	3	CH E 140A	3
CH E 128	3	CHEM 113B	4	CH E 180A	3
CH E 132B	3	MATRL 101 or MATRL 100B*	3	CHEM 113C	4
G.E. Elective	4	G.E. Elective	3	Technical or Free Elective	3
TOTAL	**15**		**16**		**16**

SENIOR YEAR

FALL	units	WINTER	units	SPRING	units
CH E 140B	3	CH E 180B	3	CH E 184B	3
CH E 152A	4	CH E 184A	3	G.E. Elective	4
CH E 170	3	G.E. Elective	4	Technical or Free Electives	7
G.E. Elective	4	Technical or Free Electives	4		
Technical or Free Elective	3				
TOTAL	**17**		**14**		**14**

* if applying to the BS/MS Materials program, juniors must take MATRL 100A in fall, MATRL 100B in winter, and MATRL 100C in spring.

COMPUTER ENGINEERING

PREPARATION FOR THE MAJOR	Units 80
CHEM 1A, 1AL, 1B, 1BL or 2A, 2AC, 2B, 2BC	10
CMPSC 16	4
CMPSC 24	4
CMPSC 32	4
CMPSC 40	4
ECE 1	1
ECE 2A-B-C	15
ECE 15A-B	6
MATH 3A-B-C, 5A	16
PHYS 1, 2, 3, 3L, 4, 4L	16

UPPER DIVISION MAJOR	61
CMPSC 130A	4
CMPSC 170	4
ECE 139 or PSTAT 120A	4
ECE 152A-B	10
ECE 154	4
ENGR 101	3

Computer Engineering electives selected from the following list: 32

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

Must include at least 2 sequences and 8 units of senior computer systems project CMPSC 189 A-B/ECE 189A-B.

CMPSC 130B	CMPSC 181B/ECE 181B
CMPSC 138	CMPSC 182/ECE 160
CMPSC 153A/ECE 153A	CMPSC 189A-B/ECE 189A-B
CMPSC 160	ECE 124A, 124D
CMPSC 162	ECE 147A-B
CMPSC 165A-B	ECE 151/CMPSC 171
CMPSC 171	ECE 153B
CMPSC 176A-B/ECE 155A-B	ECE 156A-B
CMPSC 176C	ECE 157
CMPSC 177	ECE 160
CMPSC 178	ECE 178
	ECE 181A, 181C

Computer Engineering Electives taken:

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

UNIVERSITY REQUIREMENTS	Units

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

____

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

Satisfied by: ______________________________

GENERAL EDUCATION

General Subject Areas

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

A-1: ____________ **A-2**: ____________

Areas D & E: Social Sciences, Culture and Thought
(2 courses minimum)

____________ ____________

Areas F & G: The Arts, Literature
(2 courses minimum, at least 1 from Area G)

____________ G____________

2 additional courses from Areas D, E, F, or G

____________ ____________

Special Subject Areas
(Please refer to the General Education Program Requirements booklet for more information)

Depth:

____________ ____________
____________ ____________

Ethnicity (1 course): ____________

European Traditions (1 course): ____________

Writing (4 courses required):

____________ ____________
____________ ____________

NON-MAJOR ELECTIVES	48

General Education and Free Electives taken:

TOTAL UNITS REQUIRED FOR GRADUATION 189

COMPUTER ENGINEERING

FRESHMAN YEAR

FALL	units	WINTER	units	SPRING	units
CHEM 1A or 2A	3	CHEM 1B or 2B	3	CMPSC 16	4
CHEM 1AL or 2AC	2	CHEM 1BL or 2BC	2	ECE 1	1
MATH 3A	4	MATH 3B	4	MATH 3C	4
G.E. Elective or CMPSC 8*	4	PHYS 1	4	PHYS 2	4
WRIT 1E or 2E	4	WRIT 2E or 50E	4	WRIT 50E or G.E. Elective	4
TOTAL	**17**		**17**		**17**

SOPHOMORE YEAR

FALL	units	WINTER	units	SPRING	units
CMPSC 40	4	CMPSC 24	4	CMPSC 32	4
ECE 2A	5	ECE 2B	5	ECE 2C	5
MATH 5A	4	ECE 15A	3	ECE 15B	3
PHYS 3	3	PHYS 4	3	ECE 139 or PSTAT 120A**	4
PHYS 3L	1	PHYS 4L	1		
TOTAL	**17**		**16**		**16**

JUNIOR YEAR

FALL	units	WINTER	units	SPRING	units
ECE 152A	5	CMPSC 130A	4	CMPSC 170	4
G.E. or Free Electives	12	ECE 154	4	ECE 152B	5
		G.E. or Free Electives	8	G.E. or Free Elective	4
TOTAL	**17**		**16**		**13**

SENIOR YEAR

FALL	units	WINTER	units	SPRING	units
CMPEN Electives	12	CMPEN Electives	8	CMPEN Electives	12
Free Elective	4	ENGR 101	3		
		Free Elective	4		
TOTAL	**16**		**15**		**12**

* CMPSC 8 is recommended only for students who do not have prior programming experience, as programming experience is a prerequisite for CMPSC 16.

** PSTAT 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.

COMPUTER SCIENCE

PREPARATION FOR THE MAJOR	Units 52
CMPSC 16	4
CMPSC 24	4
CMPSC 32	4
CMPSC 40	4
CMPSC 48	4
CMPSC 56	4
CMPSC 64	4
MATH 3A-B-C, 5A-B	20
PSTAT 120A	4

UPPER DIVISION MAJOR	64
CMPSC 111 or 140	4
CMPSC 130A-B	8
CMPSC 138	4
CMPSC 154/ECE 154	4
CMPSC 160	4
CMPSC 162	4
CMPSC 170	4
ECE 152A	5
ENGR 101	3
PSTAT 120B	4

Major Field Electives 20
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 undergraduate adviser.

CMPSC/MATH 109A-B-C	CMPSC 178	ECE 130A-B-C
CMPSC 111[1]	CMPSC 180	ECE 140
CMPSC 140[1]	CMPSC 181B/ECE 181B	ECE 152B
CMPSC/ECE 153A	CMPSC 182/ECE160	ECE 153B
CMPSC 165A-B	CMPSC 185	MATH 108A-B
CMPSC 167	CMPSC 186	MATH 119A-B
CMPSC 171/ECE 151	CMPSC 189 A-B	MATH 124A-B
CMPSC 172	CMPSC 190 AA-ZZ	PSTAT 122
CMPSC 174A-B	CMPSC 192[2]	PSTAT 130
CMPSC 176A-B-C	CMPSC 196[2]	PSTAT 132C
CMPSC 177		

[1]CMPSC 111 or CMPSC 140 can be used as an elective if not taken as a major course.
[2]Four units maximum from CMPSC 192 and CMPSC 196 combined; only for students with GPA of 3.0 or higher.

Major Field Electives taken:

______________________ ______________________
______________________ ______________________
______________________ ______________________

SCIENCE COURSES	20
PHYS 1, 2, 3, 3L	12
Science Electives (see Dept. for list)	8

Science Electives taken: ______________________
____

Courses required for the major, inside or outside of the Department of Computer Science, cannot be taken for the passed/not passed grading option. They must be taken for **letter** grades.

UNIVERSITY REQUIREMENTS (Units)

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

____

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

Satisfied by: ______________________________

GENERAL EDUCATION

General Subject Areas

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

A-1: ______________________ **A-2**: ______________________

Areas D & E: Social Sciences, Culture and Thought
(2 courses minimum)

______________________ ______________________

Areas F & G: The Arts, Literature
(2 courses minimum, at least 1 from Area G)

______________________ G______________________

2 additional courses from Areas D, E, F, or G

______________________ ______________________

Special Subject Areas
(Please refer to the General Education Program Requirements booklet for more information)

Depth:

______________________ ______________________
______________________ ______________________

Ethnicity (1 course): ______________________

European Traditions (1 course): ______________________

Writing (4 courses required):

______________________ ______________________
______________________ ______________________

NON-MAJOR ELECTIVES **48**

General Education and Free Electives taken:

______________________ ______________________
______________________ ______________________
______________________ ______________________
______________________ ______________________
______________________ ______________________
______________________ ______________________
______________________ ______________________

TOTAL UNITS REQUIRED FOR GRADUATION 184

COMPUTER SCIENCE

FRESHMAN YEAR

FALL	units	WINTER	units	SPRING	units
G.E. Elective or CMPSC 8*	4	CMPSC 16	4	CMPSC 24	4
MATH 3A	4	MATH 3B	4	MATH 3C	4
WRIT 1, 2, or G.E. Elective	4	PHYS 1	4	PHYS 2	4
G.E. Elective	4	WRIT 1, 2, or G.E. Elective	4	Science or Free Elective	4
TOTAL	**16**		**16**		**16**

SOPHOMORE YEAR

FALL	units	WINTER	units	SPRING	units
CMPSC 32	4	CMPSC 48	4	CMPSC 64	4
CMPSC 40	4	CMPSC 56	4	PSTAT 120A	4
MATH 5A	4	MATH 5B	4	G.E. Elective	4
PHYS 3	3	WRIT 50	4	Science or Free Elective	4
PHYS 3L	1				
TOTAL	**16**		**16**		**16**

JUNIOR YEAR

FALL	units	WINTER	units	SPRING	units
CMPSC 130A	4	CMPSC 130B	4	CMPSC / ECE 154	4
CMPSC 138	4	ECE 152A	5	PSTAT 120B	4
G.E. Elective	4	Free Elective	3	Field or Free Elective	4
Science or Free Elective	4	G.E. Elective	4	G.E. Elective	4
TOTAL	**16**		**16**		**16**

SENIOR YEAR

FALL	units	WINTER	units	SPRING	units
CMPSC 111 **	4	CMPSC 160	4	Field or Free Elective	4
CMPSC 170	4	CMPSC 162	4	Field or Free Elective	4
Field or Free Elective	4	ENGR 101	3	G.E. or Free Elective	5
		Field or Free Elective	4		
TOTAL	**12**		**15**		**13**

* CMPSC 8 is recommended only for students who do not have prior programming experience; programming experience is a prerequisite for CMPSC 16.

** or you may take CMPSC 140 in winter quarter to satisify this requirement.

ELECTRICAL ENGINEERING

PREPARATION FOR THE MAJOR	Units 83
CHEM 1A, 1AL, 1B, 1BL or 2A, 2AC, 2B, 2BC	10
CMPSC 16	4
CMPSC 24	4
ECE 2A-B-C	15
ECE 15A	3
ENGR 3	3
MATH 3A-B-C, 5A-B-C	24
PHYS 1, 2, 3, 3L, 4, 4L, 5, 5L	20

UPPER DIVISION MAJOR	68
ECE 130A-B	8
ECE 132	4
ECE 134	4
ECE 137A-B	8
ECE 139	4
ECE 152A	5
ENGR 101	3

Departmental electives selected from the following list: 32

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

Approved Departmental Electives:

ECE 124A-B-C-D	ECE 148	ECE 178
ECE 125	ECE 149	ECE 181A-B-C
ECE 130C	ECE 152B	ECE 183
ECE 135	ECE 153A-B	ECE 192 or 196 (4 unit combined max) OR ECE 188A-B
ECE 140	ECE 154	ECE 194AA-ZZ(excluding ECE 194R)
ECE 141A-B-C	ECE 155A-B	ENGR 100, 103, 185A, 185B 185C, 185D (1 course max)
ECE 144	ECE 156A-B	MATRL 100A, C
ECE 145A-B-C	ECE 158	MATRL 100B or MATRL 101
ECE 146A-B	ECE 160	MATRL 162A-B
ECE 147A-B-C	ECE 162A-B-C	

Departmental Electives taken:

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

UNIVERSITY REQUIREMENTS Units

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

____

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

Satisfied by:______________________________

GENERAL EDUCATION

General Subject Areas

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

A-1: ____________ **A-2**: ____________

Areas D & E: Social Sciences, Culture and Thought
(2 courses minimum)

____________ ____________

Areas F & G: The Arts, Literature
(2 courses minimum, at least 1 from Area G)

____________ G____________

2 additional courses from Areas D, E, F, or G

____________ ____________

Special Subject Areas

(Please refer to the General Education Program Requirements booklet for more information)

Depth:

____________ ____________
____________ ____________

Ethnicity (1 course):____________

European Traditions (1 course):____________

Writing (4 courses required):

____________ ____________
____________ ____________

NON-MAJOR ELECTIVES 42

General Education and Free Electives taken:

TOTAL UNITS REQUIRED FOR GRADUATION 193

ELECTRICAL ENGINEERING

FRESHMAN YEAR

FALL	units	WINTER	units	SPRING	units
CHEM 1A or 2A	3	CHEM 1B or 2B	3	CMPSC 16	4
CHEM 1AL or 2AC	2	CHEM 1BL or 2BC	2	MATH 3C	4
ENGR 3	3	MATH 3B	4	PHYS 2	4
MATH 3A	4	PHYS 1	4	WRIT 50E or G.E.	4
WRIT 1E or 2E	4	WRIT 2E or 50E	4		
TOTAL	**16**		**17**		**16**

SOPHOMORE YEAR

FALL	units	WINTER	units	SPRING	units
ECE 2A	5	ECE 2B	5	CMPSC 24	4
MATH 5A	4	ECE 15A	3	ECE 2C	5
PHYS 3	3	MATH 5B	4	MATH 5C	4
PHYS 3L	1	PHYS 4	3	PHYS 5	3
		PHYS 4L	1	PHYS 5L	1
TOTAL	**13**		**16**		**17**

JUNIOR YEAR

FALL	units	WINTER	units	SPRING	units
ECE 130A	4	ECE 130B	4	ECE 137B	4
ECE 132	4	ECE 137A	4	ECE 139	4
ECE 134 or ECE 152A	4/5	ECE Elective	4	ECE Elective	4
G.E. or Free Elective	4/3	G.E. or Free Elective	4	G.E. or Free Elective	4
TOTAL	**16**		**16**		**16**

SENIOR YEAR

FALL	units	WINTER	units	SPRING	units
ECE 134 or ECE 152A	4/5	ECE Electives	8	ECE Electives	8
ECE Electives	8	G.E. or Free Electives	8	ENGR 101	3
G.E. or Free Elective	4/3			G.E. or Free Electives	7
TOTAL	**16**		**16**		**18**

MECHANICAL ENGINEERING

PREPARATION FOR THE MAJOR	Units: 76
CHEM 1A, 1AL, 1B, 1BL or 2A, 2AC, 2B, 2BC	10
ENGR 3	3
MATH 3A-B-C, 5A-B-C	24
ME 6	4
ME 10	4
ME 14	4
ME 15	4
ME 16	4
ME 17	3
PHYS 1, 2, 3, 3L, 4, 4L	16

UPPER DIVISION MAJOR	70
Third Year	
MATRL 101 or MATRL 100B*	3
ME 104	3
ME 105	4
ME 140A	3
ME 151A-B	8
ME 152A-B	7
ME 153	3
ME 154	3
ME 155A	3
ME 163	3

* see note on next page

Fourth Year	
ME 151C	3
ME 156A-B	6
ME 189A-B-C	6
Engineering Electives	15

Prior approval of the student's departmental electives must be obtained from the student's faculty adviser. Note, the list of approved electives may change from year to year and that not all courses are offered each year.

Approved Engineering Electives:

CHEM 109A	ME 112	ME 158
CHEM 123	ME 114	ME 162
ECE 147A,C	ME 119	ME 166
ECE 181A,C	ME 124	ME 167
ENGR 101	ME 125AA-ZZ	ME 168
ENGR 100, 103, 185A-B-C-D (max 1 course)	ME 128, ME 134	ME 169, ME 170A,C
ENV S 105	ME 136	ME 173
MATRL 100A	ME 138	ME 185
MATRL 100C	ME 140B	ME 186
MATRL 186	ME 141A-B-C	ME 197[1]
ME 106A-B-C	ME 146	ME 199[1]
ME 110	ME 155B	

[1] Four units maximum from ME 197 and ME 199 combined.

Engineering Electives taken:

____

____

Courses required for the 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.

UNIVERSITY REQUIREMENTS

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

____

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

Satisfied by:______________________________

GENERAL EDUCATION

General Subject Areas

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

A-1: ________________ **A-2**: ________________

Areas D & E: Social Sciences, Culture and Thought
(2 courses minimum)

________________ ________________

Areas F & G: The Arts, Literature
(2 courses minimum, at least 1 from Area G)

________________ G________________

2 additional courses from Areas D, E, F, or G

________________ ________________

Special Subject Areas

(Please refer to the General Education Program Requirements booklet for more information)

Depth:

________________ ________________

________________ ________________

Ethnicity (1 course):______________________

European Traditions (1 course):______________________

Writing (4 courses required):

________________ ________________

________________ ________________

NON-MAJOR ELECTIVES 44

General Education and Free Electives taken:

____

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____

____

____

____

TOTAL UNITS REQUIRED FOR GRADUATION 190

MECHANICAL ENGINEERING

FRESHMAN YEAR

FALL	units	WINTER	units	SPRING	units
CHEM 1A or 2A	3	CHEM 1B or 2B	3	MATH 3C	4
CHEM 1AL or 2AC	2	CHEM 1BL or 2BC	2	ME 10	4
ENGR 3 or G.E. Elective	3/4	MATH 3B	4	PHYS 2	4
MATH 3A	4	PHYS 1	4	WRIT 50E, ENGR 3, or	3/4
WRIT 1E or 2E	4	WRIT 2E or 50E	4	G.E. Elective	
TOTAL	**16/17**		**17**		**15/16**

SOPHOMORE YEAR

FALL	units	WINTER	units	SPRING	units
MATH 5A	4	MATH 5B	4	MATH 5C	4
ME 14	4	ME 6	4	ME 16	4
PHYS 3	3	ME 15	4	ME 17	3
PHYS 3L	1	PHYS 4	3	G.E. Elective	4
G.E. Elective	4	PHYS 4L	1		
TOTAL	**16**		**16**		**15**

JUNIOR YEAR

FALL	units	WINTER	units	SPRING	units
ME 104	3	MATRL 101 or	3	ME 105	4
ME 140A	3	MATRL 100B*		ME 153	3
ME 151A	4	ME 151B	4	ME 154	3
ME 152A	4	ME 152B	3	ME 155A	3
G.E. or Free Elective	4	ME 163	3	G.E. or Free Elective	4
		G.E. or Free Elective	4		
TOTAL	**18**		**17**		**17**

SENIOR YEAR

FALL	units	WINTER	units	SPRING	units
ME 151C	3	ME 156B	3	ME 189C	2
ME 156A	3	ME 189B	2	Departmental Electives	6
ME 189A	2	Departmental Electives	6	G.E. or Free Electives	4
Departmental Electives	3	G.E. or Free Elective	4		
G.E. or Free Elective	4				
TOTAL	**15**		**15**		**12**

* if applying to the BS/MS Materials program, juniors must take MATRL 100A in fall, MATRL 100B in winter, and MATRL 100C in spring.

Calendar, 2009-2010

Note: Dates subject to change without notice.

	Fall 2009	*Winter 2010*	*Spring 2010*
Undergraduate admission Application filing period for undergraduate admission, to be filed with the University of California, Undergraduate Application Processing Service, P.O. Box 4010, Concord, CA 94524-4010. Web site: www.universityofcalifornia.edu/apply	November 1–30, 2008		
Undergraduate returning students Application filing period for readmission, to be filed with the Office of the Registrar by undergraduate students who have been absent for one or more quarters, who withdrew during their last quarter of attendance at UCSB, or who cancelled or had their registration lapsed.	November 1, 2008 - August 11, 2009	July 1, 2009 - November 10, 2009	October 1, 2009 - February 9, 2010
Registration begins	May 14, 2009 (Thursday)	October 24, 2009 (Saturday)	February 3, 2010 (Wednesday)
Quarter begins	September 19-20, 2009 (Saturday-Sunday)	January 4, 2010 (Monday)	March 29, 2010 (Monday)
Convocation	September 21, 2009 (Monday)		
Pre–instructional activities: Required testing, advising, meetings, and new student orientation	September 21-23, 2009 (Monday-Wednesday)	January 4, 2010 (Monday)	March 29, 2010 (Monday)
First day of instruction	September 24, 2009 (Thursday)	January 4, 2010 (Monday)	March 29, 2010 (Monday)
Last day of instruction	December 4, 2009 (Friday)	March 12, 2010 (Friday)	June 4, 2010 (Friday)
Final examinations	December 7-12, 2009 (Monday-Saturday)	March 15-20, 2010 (Monday-Saturday)	June 5-11, 2010 (Saturday-Friday)
Quarter ends	December 12, 2009 (Saturday)	March 20, 2010 (Saturday)	June 11, 2010 (Friday)
Commencement			June 12-13, 2010 (Saturday, Sunday)

Summer Sessions 2010

Registration begins: April 5, 2010

First day of instruction: June 21, 2010

Holidays

Labor Day: Monday, September 7, 2009
Veterans' Day: Wednesday, November 11, 2009
Thanksgiving: Thursday and Friday, November 26 and 27, 2009
Christmas: Thursday and Friday, December 24 and 25, 2009
New Year: Thursday and Friday, December 31, 2009 and January 1, 2010
Martin Luther King, Jr.'s Birthday: Monday, January 18, 2010
Presidents' Holiday: Monday, February 15, 2010
Cesar Chavez Holiday: Friday, March 26, 2010
Memorial Day: Monday, May 31, 2010
Independence Day: Monday, July 5, 2010