Ethical issues in research/collaborative work. (S/U grading only.) Prerequisite: consent of instructor. Special topic in Artificial Intelligence. May be repeated for credit when topic differs. — F, W, S. (F, W, S.)

289L. Special Topics in Computer Science; Computer Science (1-5)
Lecture; laboratory; lecture/laboratory. Prerequisite: consent of instructor. Special topic in Computer Graphics. May be repeated for credit when topic differs. — F, W, S. (F, W, S.)

289M. Special Topics in Computer Science; Network Security (1-5)
Lecture; laboratory; lecture/laboratory. Prerequisite: consent of instructor. Special topic in Networks. May be repeated for credit when topic differs. — F, W, S. (F, W, S.)

289N. Special Topics in Computer Science; Computer-Aided Design (1-5)
Lecture; laboratory; lecture/laboratory. Prerequisite: consent of instructor. Special topic in Computer-Aided Design. May be repeated for credit when topic differs. — F, W, S. (F, W, S.)

289Q. Special Topics in Computer Science; Scientific Computing (1-5)
Lecture; laboratory; lecture/laboratory. Prerequisite: consent of instructor. Special topic in Scientific Computing. May be repeated for credit when topic differs. — F, W, S. (F, W, S.)

289R. Special Topics in Computer Science; Computational Biology (1-5)
Lecture; laboratory; lecture/laboratory. Prerequisite: consent of instructor. Special topic in Computational Biology. May be repeated for credit when topic differs. — F, W, S. (F, W, S.)

290. Seminar in Computer Science (1)
Seminar — 1 hour. Participating seminar; discussion and presentation of current research and development in computer science. (S/U grading only.) — F, W, S. (F, W, S.)

290C. Graduate Research Group Conference (1)
Discussion — 1 hour. Research problems, progress and techniques in computer science. May be repeated for credit. (S/U grading only.) — F, W, S. (F, W, S.)

293A. Research in Computer Science (1)
Lecture — 1 hour. Prerequisite: graduate standing in computer science. Pass One and Pass Two open to Graduate Students in Computer Science only. Study of research topics in computer science, Ph.D. level research methodologies (experimental, applied and theoretical). Study skills necessary to successfully find/solve significant research problems. Finding and successful interacting with a research adviser. Ethical issues in research/collaborative work. (S/U grading only.) — F, W, S. (F, W, S.)

293B. Research in Computer Science (1)
Lecture — 1 hour. Prerequisite: graduate standing in computer science; graduate standing in computer science. 293A recommended. Pass One and Pass Two open to Graduate Students in Computer Science only. Study of Ph.D. level research methodologies (experimental, applied and theoretical), presenting research results for the computer science community. Study skills necessary to successfully find/solve significant research problems. (S/U grading only.) — W (W) Martel

298A. Group Study (1-5)
Lecture, laboratory, or combination. Prerequisite: consent of instructor. (S/U grading only.)

298C. Research (1-12)
(S/U grading only.)

Professional

390. The Teaching of Computer Science (1)
Discussion — 1 hour. Prerequisite: meet qualifications for teaching assistant and/or associate-in in Pass One and Pass Two open to Graduate Students in Computer Science only. Computer Science Computer Science. Part-time teaching assistant or associate-in in a designated engineering course. Methods of leading discussion groups or laboratory sections, writing and grading quizzes, use of laboratory equipment, and grading laboratory reports. May be repeated for credit. (S/U grading only.) — F, W, S. (F, W, S.)

396. Teaching Assistant Training Practicum (1-4)
Prerequisite: graduate standing. May be repeated for credit. (S/U grading only.)

398. Group Study (1-5)
Lecture, laboratory, or combination. Prerequisite: consent of instructor. (S/U grading only.)

Engineering: Electrical and Computer Engineering

[College of Engineering] Kent Wilken, Ph.D., Chairperson of the Department Soheil Ghiasi, Ph.D., Vice Chairperson for Undergraduate Studies Rajeevan Amirtharajah, Ph.D., Vice Chairperson for Graduate Studies Department Office. 2064 Kemper Hall 530-752-0583; http://www.ece.ucdavis.edu

Faculty
Khaled Abdel-Ghaffar, Ph.D., Professor Venkatesh Akella, Ph.D., Professor Hussain Al-Araby, Ph.D., Associate Professor Rajeevan Amirtharajah, Ph.D., Professor Bevan Baas, Ph.D., Professor G. R. Branner, Ph.D., Professor Srabanti Chowdhury, Ph.D., Associate Professor Chen-Nee Chua, Ph.D., Professor Shuguang “Robert” Cui, Ph.D., Professor Soheil Ghiasi, Ph.D., Associate Professor Q. Jane Gu, Ph.D., Associate Professor A. Nazli Gündes, Ph.D., Professor Joshua Hilleth, Ph.D., Assistant Professor Charles E. Hunt, Ph.D., Professor Paul J. Hurst, Ph.D., Professor Saif Islam, Ph.D., Professor Andre Knoesen, Ph.D., Professor H. Brian Kolner, Ph.D., Associate Professor Bernard C. Levy, Ph.D., Professor Stephen H. Lewis, Ph.D., Professor Xiaoqiang “Leo” Liu, Ph.D., Assistant Professor Neville C. Luhmann, Jr., Ph.D., Professor Omeed Momeni, Ph.D., Assistant Professor John Owens, Ph.D., Professor Anti-Vu Pham, Ph.D., Professor Erkin Seker, Ph.D., Assistant Professor Kent Wilken, Ph.D., Professor Jerry M. Woodall, Ph.D., Professor S.J. Ben Yoo, Ph.D., Professor Qing Zhao, Ph.D., Professor

Emeriti Faculty
V. Ralph Alpazari, Ph.D., Professor Emeritus Robert W. Bower, Ph.D., Professor Emeritus Tzu-Shuan Chang, Ph.D., Professor Emeritus John N. Churchill, Ph.D., Professor Emeritus Jean-Pierre Colinge, Ph.D., Professor Emeritus K. Wayne Current, Ph.D., Professor Emeritus Andrew J. Dienes, Ph.D., Professor Emeritus Richard C. Dorf, Ph.D., Professor Emeritus Herman J. Fink, Ph.D., Professor Emeritus Geert E. Ford, Ph.D., Professor Emeritus Academic Senate Distinguished Teaching Award William A. Gardner, Ph.D., Professor Emeritus Mohammad S. Ghauri, Ph.D., Professor Emeritus/ Dean Emeritus Stephen Haley, Ph.D., Professor Emeritus Jonathan P. Herriott, Ph.D., Professor Emeritus T.C. Steve Hsia, Ph.D., Professor Emeritus Vojin G. Oklobdzija, Ph.D., Professor Emeritus G.R. Redinbo, Ph.D., Professor Emeritus Ronald F. Sasaki, Ph.D., Professor Emeritus Richard K. Spencer, Ph.D., Professor Emeritus Shih-Ho Wang, Ph.D., Professor Emeritus

Affiliated Faculty
Shu Lin, Ph.D., Adjunct Professor Augusto Sarti, Ph.D., Adjunct Professor Diego Yankelevich, Ph.D., Adjunct Professor

The Electrical and Computer Engineering Undergraduate Programs
The department administers two undergraduate curricula in the College of Engineering: (1) the Electrical Engineering curriculum and (2) the Computer Engineering curriculum.

Integrated Degree Program (IDP). The IDP leads to both the Bachelor of Science and the Master of Science degrees. The program provides a student the opportunity to obtain superior breadth and depth of technical material. The IDP program in the Department of Electrical and Computer Engineering is available only to UC Davis undergraduates with strong academic records enrolled in the Electrical Engineering, Computer Engineering, Electronic Materials Engineering or Applied Physics curricula. Applicants in their junior year must apply for the IDP by March 31. For more information on IDP, see http://www.ece.ucdavis.edu.

Mission. Under its land grant status, the University of California has a mission to provide the state with the trained workforce it needs and to advance knowledge and research in directions that contribute to the general welfare of the state and the nation. The Department of Electrical and Computer Engineering contributes to the mission of the University in three ways. First, its undergraduate and graduate education programs seek to provide students with an understanding of the fundamental principles of electrical and computer engineering, the skills needed to solve the complex technological problems of modern society and the ability to continue to learn and develop throughout their careers. Second, through its research programs, the department contributes to the development and progress of electronics, communications, and computer technology. Finally, the department helps to transfer the results of its research to industry through publication, public service and professional activities.

Objectives. Teaching—to provide undergraduate students with sufficient breadth to allow them to participate in teams, continue their own education after graduation and select a focus area intelligently; to provide graduate students with sufficient depth in a narrower discipline to allow them to develop the ability to solve complex problems in the classroom and the real world; to educate the students in the graduate program to be leaders in industry or to do meaningful research in industry, government or academia. Research—to develop and maintain research programs that produce useful technological advancements while simultaneously training the next generation of researchers and leaders; to update and/or shift the foci of these programs frequently to respond to the needs of the industry and the nation; to provide a stimulating environment that encourages our graduate students to develop their abilities as far as possible.
Electrical Engineering Undergraduate Program

The Electrical Engineering program is accredited by the Engineering Accreditation Commission of ABET; see http://www.abet.org/

Electrical engineering involves the design, analysis, and effective use of electrical systems including electronic computers. Electrical systems and computers play a central role in nearly all aspects of modern life, including communication, medicine, education, entertainment, transportation, space exploration, defense, and home entertainment.

Students who complete the Electrical Engineering curriculum will obtain a Bachelor of Science in Electrical Engineering, one of the engineering degrees recognized in all fifty states as eligible for registration as a Professional Engineer.

Objectives. The Electrical Engineering program has adopted the following objectives to serve the long-term interests of our students and the industries of Northern California and the nation. Foundation—To provide our graduates with a solid foundation in engineering, including mathematics, physical science, and the fundamentals of electrical engineering. This foundation is necessary to succeed in more advanced engineering courses and to be able to continue learning throughout a career. Breadth—To provide our graduates the sufficient breadth in electrical engineering in order to understand engineering tradeoffs that cross disciplines, to contribute effectively to multidisciplinary projects and to make an informed decision about their area of specialization. Depth—To provide our graduates with sufficient depth in a specific area of electrical engineering necessary to solve complex real-world engineering problems and to contribute to a specific discipline with electrical engineering expertise. Transfer—To provide our graduates with a basic understanding of, and ability to handle correctly, ethical problems that may arise during their careers. To provide them with an understanding of the obligations to society at large.

Exclusive of General Education units, the minimum number of units for the Electrical Engineering major is 146.

Students are encouraged to adhere carefully to all prerequisite requirements. The instructor is authorized to drop students from a course for which stated prerequisites have not been completed.

Lower Division Required Courses

<table>
<thead>
<tr>
<th>UNITS</th>
<th>Courses</th>
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<tbody>
<tr>
<td>16</td>
<td>Mathematics 21A-21B-21C-21D</td>
</tr>
<tr>
<td>6</td>
<td>Mathematics 22A-22B</td>
</tr>
<tr>
<td>19</td>
<td>Physics 9A-9B-9C-9D</td>
</tr>
<tr>
<td>4</td>
<td>Chemistry 2A</td>
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<tr>
<td>4</td>
<td>Computer Science 30</td>
</tr>
<tr>
<td>8</td>
<td>Engineering 6, 17</td>
</tr>
<tr>
<td>10</td>
<td>Electrical and Computer Engineering 1</td>
</tr>
</tbody>
</table>

(Theoretical and Electronic Engineering 10 is designed for sophomore students and is not recommended for upper-division course students. Transfer and change of major students who do not take Electrical and Computer Engineering 10 will substitute four additional units of upper-division electives.)

English 3 or University Writing Program 1, 1Y or 1V or Comparative Literature 1, 2, 3, or 4, or Native American Studies 5 (grade of C- or better required) 4

Communication 1 or 3 4

Upper Division Requirements: Electrical Engineering Curriculum

Areas of Specialization

For updated recommended courses, see the department website at http://www.ece.ucdavis.edu/undergrad/undergradhandbook.html.

Physical Electronics: solid-state devices, circuits and fabrication and the theory courses supporting those subjects.

Recommended elective courses:

Core electives: Electrical and Computer Engineering 130B, 140B


Electromagnetics: microwave circuits and systems, and fiber optical systems.

Recommended elective courses:

Core electives: Electrical and Computer Engineering 130B, 140B

Design Electives with Lab: Electrical and Computer Engineering 132A, 132B. Select remaining upper-division design electives from Electrical and Computer Engineering 110B, 123C, 135

Technical electives: Select from Electrical and Computer Engineering 112 and 133


Analog Electronics: transistor- and system-level analog circuit design.

Recommended elective courses:

Core electives: Electrical and Computer Engineering 110B, 140B, 150B


Technical electives: Select from Electrical and Computer Engineering 130B, 146A

Suggested Advisers: R. Amirtharajah, Q.J. Gu, P.J. Hurst, S.H. Lewis, O. Momeni

Digital Electronics: transistor- and system-level digital circuit design.

Recommended elective courses:

Core electives: Electrical and Computer Engineering 110B, 140B, 150B

Design Electives with Lab: Electrical and Computer Engineering 118 and 180B or 172 or 183 or 195A-195B Select remaining upper-division design electives from Electrical and Computer Engineering 110B, 123A, 128, 132C, 157B, 160, 210

Technical electives: Select from Electrical and Computer Engineering 130B, 146A or 210

Suggested Advisers: R. Amirtharajah, P.J. Hurst, S.H. Lewis

Communication Controls and Signal Processing: digital communication, robotics, classical controls and communication, wireless and cellular digital communication systems, signal and image processing, and computer vision.

Recommended elective courses:

Core electives: Electrical and Computer Engineering 110B, 180B

Design Electives with Lab: Electrical and Computer Engineering 157A and 157B or 165


At least one design project course **

Suggested Advisers: Electrical and Computer Engineering 119AB, 134AB, 136AB, 181AB, 193AB, 195AB

The remaining electives may be any letter-graded upper division electrical and computer engineering course not used to satisfy another major requirement.

Computer Science and Engineering 40, 150, 152B, 163, 175, 177, or 178

Technical electives** 9

Chemistry 2B, 2C and any upper-division course except Chemistry 195 & 197

Engineering 35, 45, and any upper-division engineering course not used in satisfaction of core degree requirements, excluding Engineering 100, 160, 190 (each restricted to one unit of technical elective), 198, Computer Science Engineering 132, 153, 157, 188, 154A, & 154B (ECS 154AB courses may be used by EEE majors who did not take EEC 170). A maximum of 6 units for any combination of engineering courses numbered 190C, 197, 198, and 199 may be used.

Mathematics: any upper-division course except Mathematics 135A & 197TC

Physics: any upper-division course except 116, 137, 160 (restricted to one unit of technical elective), 195, 197T


Economics 100, 101, 102, 103, 122, 124


Upper Division Composition Requirement: One course from the following (a grade of C- or better is required): University Writing Program 1, 102AL, 104AL or passing the Upper Division Composition Exam . . . 0 or 4

* Maximum of one course appearing on both the core elective list and the design elective list may be counted in both categories.

** All design project courses are also considered design lab courses and may be counted in both categories simultaneously.

*** After completion of the upper division elective requirement (at least 8 courses, 2 core, 2 with labs, 1 project) any units in excess of 32 will count toward the technical elective requirement.

Computer Engineering Undergraduate Program

The Computer Engineering program is accredited by the Engineering Accreditation Commission of ABET; see http://www.abet.org/

Exclusion of General Education units, the minimum number of units required for the Computer Engineering undergraduate major is 148.

Students are encouraged to adhere carefully to all prerequisite requirements. The instructor is authori-
Lower Division Required Courses

<table>
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<td>7</td>
</tr>
<tr>
<td>Physics 9A-9B, 9C-9D</td>
<td>19</td>
</tr>
<tr>
<td>Chemistry 2A</td>
<td>5</td>
</tr>
<tr>
<td>Computer Engineering 20, 30, 40, 60</td>
<td>16</td>
</tr>
</tbody>
</table>

Electrical and Computer Engineering 1, 10 (Electrical and Computer Engineering 10 is designed for sophomore students and is not recommended for upper-division students. Transfer and change of major students who do not take Electrical and Computer Engineering 10 will substitute four additional units of upper-division electives.)

Engineering 17                        | 4     |

Electrical and Computer Engineering 101, 201, 202, 301, 302, 401, 402, 501, 502, 601, 602 | 12       |

Computer Engineering 122A, 122B       | 10    |

Engineering 160, 190, or Computer Science Engineering 188               | 3-4   |

Upper-Division Elective Courses: Any one course except Chemistry 195 and 197, Engineering 35, 45, and any upper-division engineering course not used in satisfaction of core degree requirements, excluding Engineering 100, 160, 190 (each restricted to one unit of technical elective), 198, Computer Science Engineering 132, 155, 157, 188, 154A, or 154B. A maximum of 6 units for any combination of engineering courses numbered 190C, 192, 198, and 199 may be used.

Mathematics: any upper-division course except Math 135A & 197TC

Chemistry 2B, 2C and any upper-division course except Chemistry 195 & 197T

Engineering 35, 45, and any upper-division engineering course not used in satisfaction of core degree requirements, excluding Engineering 100, 160, 190 (each restricted to one unit of technical elective), 198, Computer Science Engineering 132, 155, 157, 188, 154A, or 154B. A maximum of 6 units for any combination of engineering courses numbered 190C, 192, 198, and 199 may be used.

Mathematics: any upper-division course except Math 135A & 197TC

Physics: any upper-division course except 116, 137, 160 (restricted to one unit of technical elective), 195, 197T

Statistics: any upper-division course except Statistics 100, 102, 103, 104, 106, 108, 120, 130A

Biological Sciences 101, 101D, 102, 103, 104, 120F, 122, 122, 122D, 132

Economics 100, 101, 103, 102, 122, 140 Management 11A, 118, 100, 120, 140, 150, 160, 170, 180

Upper Division Composition Requirement                           | 0-4    |

One course from the following (a grade of C or better is required): University Writing Program 101, 102A, 104A-T or passing the Upper Division Composition Exam.

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Electrical Engineering Minor

There has been an increasing need for professionals in most engineering disciplines to understand the fundamentals of electronic circuits, electronic signals, semiconductor devices, applied electromagnetics, control systems, computer systems, and communication systems.

The objective of this minor program is to prepare students with the necessary theoretical and practical training in one or many of the above mentioned fields. The minor program curriculum is designed to allow flexibility while ensuring a solid foundation of fundamental electrical engineering concepts. The program is expected to accommodate students of diverse backgrounds.

The minor must be outside the department or program of your major. If no more than one course may be counted toward both your minor and your major, the courses you take to satisfy the requirements of a minor, including those completed elsewhere, must be approved by an advisor in the Department of Electrical and Computer Engineering. You must have a minimum overall GPA of 2.000 and satisfy the minor course requirements, listed below. To receive notation of a minor on your diploma, you must obtain a minor petition and file it no later than the deadline for filing for graduation.

Minor Requirements

- Mathematics: any upper-division course except Chemistry 195, 197T, Engineering 35, 45, and any upper-division engineering course not used in satisfaction of core degree requirements, excluding Engineering 100, 160, 190 (each restricted to one unit of technical elective), 198, Computer Science Engineering 132, 155, 157, 188, 154A, or 154B. A maximum of 6 units for any combination of engineering courses numbered 190C, 192, 198, and 199 may be used.

- Chemistry 2B, 2C and any upper-division course except Chemistry 195 and 197T.

- Mathematics: any upper-division course except Math 135A & 197TC.

- Physics: any upper-division course except 116, 137, 160 (restricted to one unit of technical elective), 195, 197T.

- Statistics: any upper-division course except Statistics 100, 102, 103, 104, 106, 108, 120, 130A.

- Biological Sciences 101, 101D, 102, 103, 104, 120F, 122, 122, 122D, 132.


- Upper Division Composition Requirement

- Computer Science Engineering 132, 155, 157, 188, 154A, or 154B.

- Any additional units of upper-division electives.

Electrical Engineering 100

At least one of the following combinations:

- Analog circuits: Electrical and Computer Engineering 110A and 110B

- Electromagnetics: Electrical and Computer Engineering 130A and 130 B

- Physical Electronics: Electrical and Computer Engineering 140A and 140B

- Signals and Systems: Electrical and Computer Engineering 150A and 150B

- Communication: Electrical and Computer Engineering 150A and 150B

- Control Systems: Electrical and Computer Engineering 150A and 157A

Digital Systems: Electrical and Computer Engineering 180A and 180B

At least 8 additional units of Electrical and Computer Engineering courses numbered 101 or above, except for Electrical and Computer Engineering 190, 192, 196, 197, 198, 199, 298, 299, 390, and 396. (If you elect to do a design project, you must be registered for both quarters.]

- Minor Advisers: Z. Ding, X. Liu

The Graduate Program in Electrical and Computer Engineering

M.S. and Ph.D.

http://www.ece.ucdavis.edu

530-752-8251

The Department of Electrical and Computer Engineering prepares graduate students to do meaningful research and acquire skills and insights vital to solving some of the world’s most complex technological problems. Our graduate program offers a challenging and stimulating environment, covering a broad range of topics in electrical and computer engineering.

Research Highlights:

- Sandia National Laboratory
- California Lighting Technology Center
- Planetlab Consortium
- Z. Ding, X. Liu

Generous financial support is available in the form of teaching assistantships, research assistantships, and fellowships. For more information, please visit the following websites:

http://www.ece.ucdavis.edu

Courses in Engineering: Electrical and Computer Engineering (EEC)

Lower Division

1. Introduction to Electrical and Computer Engineering (1)

Lecture—1 hour. Electrical and Computer Engineering as a professional activity. An introduction to electrical and computer engineers know and how they use their knowledge. P/NP grading only. GE credit: SE. W—F.

2. Introduction to Digital and Analog Systems (3)

Lecture—1 hour; laboratory—3 hours. Prerequisite: Computer Science Engineering 30, and Physics 9C or 9HD (may be taken concurrently); consent of instructor. An introduction to the design and analysis of digital and analog systems, with an emphasis on system-level design.

3. Computer Structure and Assembly Language (4)


Research Highlights:

- Communications, control, networking, and signal processing
- Computer engineering
- Electronic circuits
- Optoelectronics
- RF, micro- and millimeter waves
- Physical electronics

Research Facilities and Partnerships:

- Center for Information Technology in the Interest of Society
- Northern California Center for Nanotechnology
- Center on Polymer Interfaces and Macromolecules
- Lawrence Livermore National Laboratory
- Lawrence Berkeley National Laboratory
- Los Alamos National Laboratory
- California Lighting Technology Center
- Planetlab Consortium
- Sandia National Laboratory

Complete Information on our website.
89D. Special Topics in Signals and Systems (1-5)
Prerequisite: consent of instructor. Special topics in Signals and Systems. May be repeated for credit if topics differ. Offered irregularly. GE credit: SciEng | SE.

89E. Special Topics in Computer Systems and Software (1-5)
Prerequisite: consent of instructor. Special topics in Computer Systems and Software. May be repeated for credit if topics differ. Offered irregularly. GE credit: SciEng | SE.

89F. Special Topics in Digital System Design (1-5)
Prerequisite: consent of instructor. Special topics in Digital System Design. May be repeated for credit if topics differ. Offered irregularly. GE credit: SciEng | SE.

90C. Research Group Conference in Electrical and Computer Engineering (1)
Discussion—1 hour. Prerequisite: consent of instructor; lower division standing. Research group conferences. May be repeated for credit. (P/NP grading only.)—F, W, S. (F, W, S.)

90X. Lower Division Seminar (1-4)
Seminar—1 hour. Prerequisites: consent of instructor. Examination of a special topic in a small group setting. May be repeated for credit.

92. Internship in Electrical and Computer Engineering (1-5)
Internship—3 hours. Prerequisite: divisional project approval prior to period of internship. Supervised work experience in Electrical and Computer Engineering. May be repeated for credit. (P/NP grading only.)

98. Directed Study Group (1-5)
Prerequisite: consent of instructor. (P/NP grading only.)

99. Special Study for Lower Division Students (1-5)
(P/NP grading only.)

Upper Division

100. Circuits II (5)
Laboratory—3 hours; lecture—3 hours; discussion—1 hour. Prerequisite: Engineering 17, C- or better. Restricted to the following majors: Electrical Engineering, Computer Engineering, Computer Science & Engineering, Electronic Materials Engineering, Electrical Engineering/Materials Science, Optical Science & Engineering, Biomedical Engineering, Applied Physics, Electrical & Computer Engineering graduate students. Theory, application, and design of analog circuits. Mathematical analysis including functional responses, feedback, interconnections, and transformations. Operational amplifiers and design of analog filters. Students who have completed Engineering 100 may receive 3 units of credit. GE credit: SciEng | SE, VL, F, W, F, W. (F, W, S.)

110A. Electronic Circuits I (4)
Lecture—3 hours; discussion—1 hour. Prerequisite: course 110A. Analysis and design of integrated circuits. Single-stage amplifiers, cascaded amplifier stages, differential amplifiers, current sources, frequency response, and non-linearity. GE credit: SciEng | SE, VL, W, S. (S.)

110B. Electronic Circuits II (4)
Lecture—3 hours; laboratory—3 hours. Prerequisite: course 110A. Analysis and design of integrated circuits. Single-stage amplifiers, cascaded amplifier stages, differential amplifiers, current sources, frequency response, and non-linearity. GE credit: SciEng | SE, VL, W, S. (S.)

112. Communication Electronics (4)
Lecture—3 hours; laboratory—3 hours. Prerequisite: course 110A and 150A; course 110B recommended. Electronic circuits for analog and digital communication, including oscillators, mixers, tuned amplifiers, modulators, demodulators, and phase-locked loops. Circuits for amplitude modulation (AM) and frequency modulation (FM) are emphasized. GE credit: SciEng | SE, W. (W.)

116. VLSI Design (4)
Lecture—3 hours; laboratory—3 hours. Prerequisite: course 110A; course 180A recommended. CMOS devices, layout, circuits, and functional units; VLSI fabrication and interconnection methodologies. GE credit: SciEng | SE, F, F. (F)

118. Digital Integrated Circuits (4)
Lecture—3 hours; laboratory—3 hours. Prerequisite: course 110A, 180A. Analysis and design of digital integrated circuits with emphasis on CMOS logic circuit families. Logic gate construction, voltage transfer characteristics, propagation delay, and power consumption. Regenerative circuits, sequential elements, interconnect, RAMs, ROMs, and PLAs. GE credit: SciEng | SE, S. (S.)

119A. Integrated Circuit Design Project (3)
Workshop—1 hour; laboratory—6 hours. Prerequisite: course 116 or 118. Design course involving architecture, circuit design, physical design, and validation through extensive simulation of a digital or mixed-signal integrated circuit of substantial complexity under given design constraints. Team project that includes a final report. (Deferred grading only, pending completion of sequence.) GE credit: SciEng | SE, W, W. (W, W.)

119B. Integrated Circuit Design Project (3)
Workshop—1 hour; laboratory—6 hours. Prerequisite: course 116 or 118. Design course involving architecture, circuit design, physical design, and validation through extensive simulation of a digital or mixed-signal integrated circuit of substantial complexity under given design constraints. Team project that includes a final report. (Deferred grading only, pending completion of sequence.) GE credit: SciEng | SE, W, W. (W, W.)

130A. Electromagnetics I (4)

130B. Introductory Electromagnetics II (4)
Lecture—3 hours; discussion—1 hour. Prerequisite: course 120A. Plane wave propagation in lossy media, reflection and refraction, simple modulated waves and dispersion, and basic antennas. GE credit: SciEng | SE, S. (S.)

132A. RF and Microwave Circuits in Wireless Communication (4)
Lecture—3 hours; laboratory—3 hours; discussion—1 hour. Prerequisite: course 110A, 130B. Study of Radio Frequency and Microwave theory and practice for design of wireless electronic systems. Transmission lines, microwave integrated circuits, circuit analysis of electromagnetic energy transfer systems, the scattering parameters. GE credit: SciEng | SE, F, W, W, F, W. (F, W, W.)

132B. RF and Microwave Circuits in Wireless Communication (5)
Lecture—3 hours; laboratory—3 hours; discussion—1 hour. Prerequisite: course 132A. Passive RF and microwave design, analysis, fabrication, and testing for wireless applications. RF and microwave filter and coupler design. Introductory analysis and design of RF and microwave transistor amplifiers. GE credit: SciEng | SE, F, W, W, F, W. (F, W, W.)

132C. RF and Microwave Circuits in Wireless Communication (5)
Lecture—3 hours; laboratory—3 hours; discussion—1 hour. Prerequisite: course 132B. RF and microwave amplifier design, including transistor circuit models, stability considerations, noise models and low noise design. Theory and design of microwave transistor oscillators and mixers. Wireless system design and analysis. GE credit: SciEng | SE, S. (S.)

133. Electromagnetic Radiation and Antenna Analysis (4)
Lecture—3 hours; discussion—1 hour. Prerequisites: course 130B. Properties of electromagnetic radiation, analysis and design of antennas: ideal cylindrical, small loop, aperture, and arrays; antenna field measurements. GE credit: SciEng | SE, S. (S.)

134A. RF/Microwave Systems Design (3)
Workshop—3 hours; laboratory—6 hours. Prerequisites: course 130B or 110B or 150A. Class size limited to 24 students. Board-level RF design, fabrication, and characterization of an RF/microwave system, including the antenna, RF frontend, baseband, mix-signal circuits, and digital signal processing models. (Deferred grading only, pending completion of sequence.) GE credit: SciEng | SE, F, F, F. (F, F, F)

134B. RF/Microwave Systems Design (3)
Workshop—3 hours; laboratory—6 hours. Prerequisites: course 134A. Class size limited to 24 students. Board-level RF design, fabrication, and characterization of an RF/microwave system, including the antenna, RF frontend, baseband, mix-signal circuits, and digital signal processing models. (Deferred grading only, pending completion of sequence.) GE credit: SciEng | SE, F, F, F. (F, F, F)

135. Optical Communications I: Fibers (4)

136A. Electronic Design Project (3)
Workshop—1 hour; laboratory—6 hours. Prerequisite: Computer Science Engineering 30; courses 100, 180A; and either 110B, 157A (may be taken concurrently), or 180B. Pass One restricted to major. Course covers digital and analog system design of an opto-electronic system operating under performance and economic constraints. Measurement techniques will be designed and implemented, and the system will be characterized. (Deferred grading only, pending completion of sequence.) GE credit: SciEng | SE, F, F, F. (F, F, F)

136B. Electronic Design Project (3)
Workshop—1 hour; laboratory—6 hours. Prerequisite: course 136A. Optical, electronic and communication-engineering design of an opto-electronic system operating under performance and economic constraints. Measurement techniques will be designed and implemented, and the system will be characterized. (Deferred grading only, pending completion of sequence.) GE credit: SciEng | SE, W, W, W. (W, W, W)

140A. Principles of Device Physics I (4)
Lecture—3 hours; discussion—1 hour. Prerequisite: Engineering 17; Physics 9D or 9HE. Semiconductor device fundamentals, equilibrium and non-equilibrium statistical mechanics, conductivity, diffusion, electrons and holes, pn junctions, first-order metal-oxide-semiconductor (MOS) field effect transistors, bipolar junction transistor fundamentals. GE credit: SciEng | SE, F, S. (F, S)

140B. Principles of Device Physics II (4)
Lecture—3 hours; discussion—1 hour. Prerequisite: course 140A. Electrical properties, designs, models and advanced concepts for MOS, Bipolar, and Junction Field-Effect Transistors, including scaling, minority carrier distributions, non-ideal effects, and device fabrication methods. MESFET and heterojunction bipolar transistors (HBTs). Fundamentals of solar cells, photodetectors, LEDs and semiconductor lasers. GE credit: SciEng | SE, S. (S)

145. Electronic Materials (4)
Lecture—3 hours; discussion—1 hour. Prerequisite: course 140A. Electronic and physical properties of materials used in electronics, ICs, optoelectronics and MEMS. Semiconductors, dielectrics, metals, optical materials, organic semiconductors, optical...
Lecture—2 hours; discussion—1 hour. Prerequisite: course 100; Engineering 6 or Mathematics 22AL. Probabilistic and statistical analysis of electrical and computer systems. Discrete and continuous random variables, expectation and moments, transformation of random variables. Joint and conditional densities. Limit theorems and statistics. Noise models, system reliability and testing. GE credit: SciEng | SE — F, S, (F, S).

165. Statistical and Digital Communication (4)

170. Introduction to Computer Architecture (4)
Lecture—3 hours; discussion—1 hour. Prerequisite: course 180A, Computer Science Engineering 30. Introduces basic aspects of computer architecture, including computer performance measurement, instruction set design, computer arithmetic, pipelined/non-pipelined, implementation, and memory hierarchies (cache and virtual memory). Presents a simplified Reduced Instruction Set Computer using logic design methods from the prerequisite course. GE credit: SciEng | SE — F, (F).

171. Parallel Computer Architecture (4)
Lecture—3 hours; discussion—1 hour. Prerequisite: course 170 or Computer Science Engineering 154B. Organization and design of parallel processors including shared memory multiprocessors, cache coherence, memory consistency, snooping protocols, synchronization, scalable multiprocessors, message passing protocols, distributed shared memory and interconnection networks. GE credit: SciEng | SE — S (F).

172. Embedded Systems (4)
Lecture—2 hours; laboratory—6 hours. Prerequisite: course 100; and course 170 or Computer Science Engineering 154A. Introduction to embedded-system hardware and software. Topics include: embedded processor and memory architecture; input/output hardware and software, including interrupts and direct memory access; interfacing with sensors and actuators; and device drivers for embedded networking. GE credit: SciEng | SE — W, S (W).

173A. Computer Networks (4)
Lecture—3 hours; discussion—1 hour. Prerequisite: Computer Science Engineering 60; Computer Science and Engineering 161; or Mathematics 135A. Topics include file transfer, mail, group communication, distributed shared memory, and database management. Practical work in teams to implement and debug a communication protocol. GE credit: SciEng | SE — W, S (W).

173B. Design Projects in Communication Networks (4)
Lecture—3 hours; discussion—1 hour. Prerequisite: course 173A or Computer Science and Engineering 152A. Advanced topics and design projects in communication networks. Example topics include wireless networks, multimedia networking, network design and management, traffic analysis and modeling, network simulations and performance analysis. (Same course as Computer Science Engineering 152C.) Offered in alternate years. GE credit: SciEng | SE — S (F).

180A. Digital Systems I (5)
Lecture—3 hours; laboratory—6 hours. Prerequisite: Physics 9C or 9HD. Introduction to digital system design including combinational logic design, sequential and asynchronous circuits, computer arithmetic, memory systems and algorithmic state machine design; computer aided design (CAD) methodologies and tools. GE credit: SciEng | SE — F, W, (W).

180B. Digital Systems II (5)
Lecture—3 hours; laboratory—6 hours. Prerequisite: course 180A. Computer-aided design of digital systems with emphasis on hardware description languages (VHDL), logic synthesis, and field-programmable gate arrays (FPGA). May cover other topics in system design such as static timing analysis, pipelining, memory system design, testing digital circuits. GE credit: SciEng | SE — S (F).

181A. Digital Systems Design Project (3)
Workshop—1 hour; laboratory—6 hours. Prerequisite: courses 180B and either course 170 or Computer Science 122A. Digital-system and computer-engineering design course involving architecture, design, implementation and testing of a prototype application-specific processor under given design constraints. This is a team project that includes a final presentation and report. (Deferred grading only. pending completion of sequence.) GE credit: SciEng | SE — W, (W).

181B. Digital Systems Design Project (3)
Workshop—1 hour; laboratory—6 hours. Prerequisite: course 181A. Digital-system and computer-engineering design course involving architecture, design, implementation and testing of a prototype application-specific processor under given design constraints. This is a team project that includes a final presentation and report. (Deferred grading only. pending completion of sequence.) GE credit: SciEng | SE — S (F).

183. Testing and Verification of Digital Systems (5)
Lecture—3 hours; laboratory—4 hours. Prerequisite: courses 170 and 180B. Computer-aided testing and design verification techniques for digital systems; physical fault testing; simulation-based design verification; formal verification; test generation and analysis. GE credit: SciEng | SE — W, S (W).

189A. Special Topics in Electrical Engineering and Computer Science; Computer Science (1-5)
Lecture; laboratory; lecture/laboratory. Prerequisite: consent of instructor. Special topic in Computer Science. May be repeated for credit when topic differs. Offered irregularly. GE credit: SciEng | SE — F, W, S (F).

189B. Special Topics in Electrical Engineering and Computer Science; Programming Systems (1-5)
Lecture; laboratory; lecture/laboratory. Prerequisite: consent of instructor. Special topic in Programming Systems. May be repeated for credit when topic differs. Offered irregularly. GE credit: SciEng | SE — F, W, S (F).

189C. Special Topics in Electrical Engineering and Computer Science; Digital Systems (1-5)
Lecture; laboratory; lecture/laboratory. Prerequisite: consent of instructor. Special topics in Digital Systems. May be repeated for credit when topic differs. Offered irregularly. GE credit: SciEng | SE — F, W, S (F).
189D. Special Topics in Electrical Engineering and Computer Science; Communication Systems (1-5)
Lecture; laboratory; lecture/laboratory. Prerequisite: consent of instructor. Special topics in Communications. May be repeated for credit when topic differs. Offered irregularly. GE credit: SciEng | SE — F, W, S. (F, W, S.)

189E. Special Topics in Electrical Engineering and Computer Science; Signal Transmission (1-5)
Lecture; laboratory; lecture/laboratory. Prerequisite: consent of instructor. Special topics in Signal Transmission. May be repeated for credit when topic differs. Offered irregularly. GE credit: SciEng | SE — F, W, S. (F, W, S.)

189F. Special Topics in Electrical Engineering and Computer Science; Digital Communication (1-5)
Lecture; laboratory; lecture/laboratory. Prerequisite: consent of instructor. Special topics in Digital Communication. May be repeated for credit when topic differs. Offered irregularly. GE credit: SciEng | SE — F, W, S. (F, W, S.)

189G. Special Topics in Electrical Engineering and Computer Science; Control Systems (1-5)
Lecture; laboratory; lecture/laboratory. Prerequisite: consent of instructor. Special topics in Control Systems. May be repeated for credit when topic differs. Offered irregularly. GE credit: SciEng | SE — F, W, S. (F, W, S.)

189H. Special Topics in Electrical Engineering and Computer Science; Robotics (1-5)
Lecture; laboratory; lecture/laboratory. Prerequisite: consent of instructor. Special topics in Robotics. May be repeated for credit when topic differs. Offered irregularly. GE credit: SciEng | SE — F, W, S. (F, W, S.)

189I. Special Topics in Electrical Engineering and Computer Science; Image Processing (1-5)
Lecture; laboratory; lecture/laboratory. Prerequisite: consent of instructor. Special topics in Image Processing. May be repeated for credit when topic differs. Offered irregularly. GE credit: SciEng | SE — F, W, S. (F, W, S.)

189K. Special Topics in Electrical Engineering and Computer Science; High-Frequency Phenomena and Devices (1-5)
Lecture; laboratory; lecture/laboratory. Prerequisite: consent of instructor. Special topics in High-Frequency Phenomena and Devices. May be repeated for credit when topic differs. Offered irregularly. GE credit: SciEng | SE — F, W, S. (F, W, S.)

189L. Special Topics in Electrical Engineering and Computer Science; Systems Theory (1-5)
Lecture; laboratory; lecture/laboratory. Prerequisite: consent of instructor. Special topics in Systems Theory. May be repeated for credit when topic differs. Offered irregularly. GE credit: SciEng | SE — F, W, S. (F, W, S.)

189M. Special Topics in Electrical Engineering and Computer Science; Digital Communication (1-5)
Lecture; laboratory; lecture/laboratory. Prerequisite: consent of instructor. Special topics in Digital Communication. May be repeated for credit when topic differs. Offered irregularly. GE credit: SciEng | SE — F, W, S. (F, W, S.)

189N. Special Topics in Electrical Engineering and Computer Science; Active and Passive Circuits (1-5)
Lecture; laboratory; lecture/laboratory. Prerequisite: consent of instructor. Special topics in Active and Passive Circuits. May be repeated for credit when topic differs. Offered irregularly. GE credit: SciEng | SE — F, W, S. (F, W, S.)

189O. Special Topics in Electrical Engineering and Computer Science; Integrated Circuits (1-5)
Lecture; laboratory; lecture/laboratory. Prerequisite: consent of instructor. Special topics in Integrated Circuits. May be repeated for credit when topic differs. Offered irregularly. GE credit: SciEng | SE — F, W, S. (F, W, S.)

189P. Special Topics in Electrical Engineering and Computer Science; Computer Software (1-5)
Lecture; laboratory; lecture/laboratory. Prerequisite: consent of instructor. Special topics in Computer Software. May be repeated for credit when topic differs. Offered irregularly. GE credit: SciEng | SE — F, W, S. (F, W, S.)

189Q. Special Topics in Electrical Engineering and Computer Science; Microprocessors (1-5)
Lecture; laboratory; lecture/laboratory. Prerequisite: consent of instructor. Special topics in Microprocessors. May be repeated for credit when topic differs. Offered irregularly. GE credit: SciEng | SE — F, W, S. (F, W, S.)

189R. Special Topics in Electrical Engineering and Computer Science; High-Frequency Phenomena and Devices (1-5)
Lecture; laboratory; lecture/laboratory. Prerequisite: consent of instructor. Special topics in High-Frequency Phenomena and Devices. May be repeated for credit when topic differs. Offered irregularly. GE credit: SciEng | SE — F, W, S. (F, W, S.)

189S. Special Topics in Electrical Engineering and Computer Science; Electromagnetics (1-5)
Lecture; laboratory; lecture/laboratory. Prerequisite: consent of instructor. Special topics in Electromagnetics. May be repeated for credit when topic differs. Offered irregularly. GE credit: SciEng | SE — F, W, S. (F, W, S.)

189T. Special Topics in Electrical Engineering and Computer Science; Opto-Electronics (1-5)
Lecture; laboratory; lecture/laboratory. Prerequisite: consent of instructor. Special topics in Opto-Electronics. May be repeated for credit when topic differs. Offered irregularly. GE credit: SciEng | SE — F, W, S. (F, W, S.)

120. Internship in Electrical and Computer Engineering (1-5)
Internship—1-5 hours. Prerequisite: completion of a minimum of 84 units; project approval before period of internship; consent of instructor. Supervised work experience in electrical and computer engineering. May be repeated for credit if project is different. (P/NP grading only.) GE credit. SE — F, W, S. (F, W, S.)

193A. Senior Design Project (3)
Workshop—1 hour; laboratory—6 hours. Prerequisite: course 196 (may be taken concurrently); consent of instructor. Restricted to senior standing in Electrical or Computer Engineering. Team design project for seniors in Electrical or Computer Engineering. Project involves analysis, design, implementation and evaluation of an Electrical Engineering or Computer Engineering system. Project supervised by a faculty member. (Deferred grading only, pending completion of sequence.) GE credit: SciEng | SE — F, W, S. (F, W, S.)

193B. Senior Design Project (3)
Workshop—1 hour; laboratory—6 hours. Prerequisite: course 193A. Team design project for seniors in Electrical Engineering or Computer Engineering. Team design project for seniors in Electrical Engineering or Computer Engineering. Project involves analysis, design, implementation and evaluation of an Electrical Engineering or Computer Engineering system. Project supervised by a faculty member. (Deferred grading only, pending completion of sequence.) GE credit: SciEng | SE — F, W, S. (F, W, S.)

193C. Research Group Conferences in Electrical Engineering (1)
Discussion—1 hour; discussion/laboratory—2-8 hours. Prerequisite: upper division standing; consent of instructor. Discussion on various electrical and computer engineering standards and real-time design issues, including economic, manufacturability, sustainability, ethical, health and safety, environmental, social, and political. GE credit. SciEng | SE — F. (F.)

193D. Directed Group Study (1-5)
Prerequisite: consent of instructor. May be repeated three times for credit. (P/NP grading only.) GE credit: SE.

193E. Directed Group Study (1-5)
Prerequisite: consent of instructor. (P/NP grading only)

Graduate

201. Digital Signal Processing (4)
Lecture—4 hours. Prerequisite: course 150B; Statistics 120 or Mathematics 131 or Mathematics 167 recommended. Theory and design of digital filters.
Classification of digital filters, linear phase systems, all-pass functions, FIR and IIR filter design methods and optimization for speed and memory. Introduction to commercially robust structures for digital filters. —W (W)

202. Advanced Digital Signal Processing (4) Lecture—4 hours. Prerequisite: courses 201, 206, and 265, and Mathematics 167 are recommended. Multirate theory and wavelets, optimal transforms and subband coders in data compressions, advanced sampling theory and oversampled A/D converters, transmultiplexers and precoders in digital communication systems, synchro digital signal processing. Offered in alternate years. —S (S)

205. Computational Methods in Biomedical Imaging (4) Lecture—4 hours. Prerequisite: Biomedical Engineering 103 and Biomedical Engineering 108 or course 150A. Analytic tomographic reconstructions from projections in 2D and 3D; model-based image reconstruction methods; maximum likelihood and Bayesian methods; applications to CT, PET, and SPECT. (Same course as Biomedical Engineering 252.) —W (W)

206. Digital Image Processing (4) Lecture—3 hours; laboratory—3 hours. Prerequisite: course 218B or 101A. Design of advanced digital filtering devices, image perception, sampling and quantization, transform theory and applications, enhancement, filtering and restoration, image analysis, and image processing systems. —W (W)

210. MOS Analog Circuit Design (3) Lecture—3 hours. Prerequisite: course 140A and 110B. Analysis and design of MOS amplifiers, bias circuits, voltage references and other analog circuits. Stabilized design optimization of feedback amplifiers. Introduction to noise analysis in MOS circuits. —F (F)

211. Advanced Analog Circuit Design (3) Lecture—3 hours. Prerequisite: course 210; Statistics 131A is recommended. Noise and distortion in electronic circuits and systems. Application to communication circuits. Specific applications include mixers, low-noise amplifiers, power amplifiers, phase-locked loops, oscillators and receiver architectures. Offered in alternate years. —W (W)


213. Data-Conversion Techniques and Circuits (3) Lecture—3 hours. Prerequisite: course 210. Digital-to-analog and analog-to-digital conversion; component characteristics and matching; sample-and-hold, comparator, amplifier, and reference circuits. —S (S)


215. Circuits for Digital Communications (3) Lecture—3 hours. Prerequisite: courses 150B and 218B (may be taken concurrently). course 165 or 265; DSP theory. Operational amplifiers, digital-to-analog and analog-to-digital CMOS implementations of communication-circuit blocks; gain control, adaptive equalizers, sampling and de-tripler, clock recovery. Offered in alternate years. —F (F)


217. Biomedical Electronics (4) Lecture—3 hours; project. Prerequisite: course 210 or consent of instructor. Equilibrium plasma properties; single particle motion; fluid equations; waves and instabilities in a fluid plasma; plasma kinetic theory and transport coefficients; linear and nonlinear Vlasov theory; fluctuations, correlations and radiation; inertial and magnetic confinement systems in controlled fusion. Offered in alternate years. —S (S)

219. Advanced Digital Circuit Design (3) Lecture—3 hours. Prerequisite: courses 118 or 218A. Analysis and design of digital circuits. Both bipolar and MOS circuits. Transistor logic and static RAM cells and sense amplifiers. Advanced MOS families. Multi-valued logic. —S (S)

221. Analog Filter Design (3) Lecture—3 hours. Prerequisite: courses 100 and 150A. Design of active and passive filters including filter specification and approximation theory. Passive IC filter design will cover doubly-terminated reactance two-port synthesis. Active filter design will include sensitivity analysis in building blocks, cascode, multi-loop, ladder and active-R filter design. Offered in alternate years. —F(2).

222. RF IC Design (3) Lecture—3 hours. Prerequisite: courses 132C and 210. Radio-frequency ICs: introduction to the technology. Passive and active device design. RF device modeling and design rules; non-linear RF circuit design techniques; use of non-linear computer-aided (CAD) tools; RF power amplifier design. Offered in alternate years. —F (F)


229. RF MEMS and Adaptive Wireless Frontends (4) Lecture—3 hours; discussion—3 hours. Prerequisite: course 130A. Focuses on the modeling, design, fabrication, and characterization of RF-MEMS while providing a thorough introduction to the technology with an emphasis on how it will benefit the design of adaptive RF/microwave wireless systems. Offered in alternate years. —S (S)

230. Electromagnetics (3) Lecture—3 hours. Prerequisite: course 130B. Maxwell’s equations, plane waves, reflection and refraction, complex waves, waveguides, resonant cavities, and basic antennas. —F (F)

231A. Plasma Physics and Controlled Fusion (3) Lecture—3 hours. Prerequisite: consent of instructor. Equilibrium plasma properties; single particle motion; fluid equations; waves and instabilities in a fluid plasma; plasma kinetic theory and transport coefficients; linear and nonlinear Vlasov theory; fluctuations, correlations and radiation; inertial and magnetic confinement systems in controlled fusion. Offered in alternate years. —S (S)

231B. Plasma Physics and Controlled Fusion (3) Lecture—3 hours. Prerequisite: course 231A; consent of instructor. Equilibrium plasma properties; single particle motion; fluid equations; waves and instabilities in a fluid plasma; plasma kinetic theory and transport coefficients; linear and nonlinear Vlasov theory; fluctuations, correlations and radiation; inertial and magnetic confinement systems in controlled fusion. Offered in alternate years. —S (S)

232A. Advanced Applied Electromagnetics I (3) Lecture—3 hours. Prerequisite: course 132B. The exact formulation of applied electromagnetic problems using Green’s functions. Application of these techniques to transmission circuits. Offered in alternate years. —W (W)

232B. Advanced Applied Electromagnetics II (4) Lecture—3 hours; laboratory—3 hours. Prerequisite: course 132B. Advanced treatment of electromagnetic applications with passive microwave circuits and antennas. —S (S)

233. High Speed Signal Integrity (3) Lecture—3 hours. Prerequisite: course 130B. Design and analysis of interconnects in high-speed circuits and sub-systems; understanding of high-speed signal propagation and signal integrity concepts; electromagnetic modeling tools and experimental techniques. Offered in alternate years. —S (S)

234A. Physics and Technology of Microwave Vacuum Electron Beam Devices I (4) Lecture—4 hours. Prerequisite: B.S. degree in physics or electrical engineering or the equivalent background. Physics and technology of electron beam emissions, field and transport, electron gun design, space-charge waves and klystrons. Offered in alternate years. —F (F)

234B. Physics and Technology of Microwave Vacuum Electron Beam Devices II (4) Lecture—4 hours. Prerequisite: course 234A. Theory and experimental design of traveling wave tubes, backward wave oscillators, and extended interaction oscillators. Offered in alternate years. —W (W)

234C. Physics and Technology of Microwave Vacuum Electron Beam Devices III (4) Lecture—4 hours. Prerequisite: course 234A. Physics and technology of gyrotrons, gyrotrons, free electron lasers, magnetrons, crossed-field amplifiers and relativistic devices. Offered in alternate years. —S (S)

235. Photonics (4) Lecture—3 hours; project—1 hour. Prerequisite: course 230 (may be taken concurrently). Optical propagation of electromagnetic waves and beams in photonic components and the design of such devices using numerical techniques. Offered in alternate years. —W (W)

236. Nonlinear Optical Applications (3) Lecture—3 hours. Prerequisite: course 130B, course 230 (may be taken concurrently). Nonlinear optical interactions in optical communication, optical information processing and integrated optics. Basic concepts underlying optical nonlinear interactions in materials and guided media. Not open for credit to students who have completed course 233. Offered in alternate years. —F (F)

237A. Lasers (3) Lecture—3 hours. Prerequisite: course 130B or the equivalent and course 235. Theoretical and practical description of lasers. Theory of population inversion, amplification and oscillation using semclassical oscillator model and rate equations. Description and design of real laser system (Not open for credit to students who have completed course 226A.) Offered in alternate years. —F (F)

238. Semiconductor Diode Lasers (3)  Lecture—3 hours; prerequisite: course 245A. Understanding of fundamental optical transitions in semiconductor and quantum-confined systems are applied to diode lasers and selected photonic devices. The importance of radiative and non-radiative recombination, simulated emission, excitons in quantum wells, and strained quantum layers are considered. Offered in alternate years. — S.


240. Semiconductor Device Physics (3)  Lecture—3 hours. Prerequisite: course 140B. Physical principles, characteristics and models of fundamental semiconductor device types, including PN and Schottky diodes, MOSFETs and MESFETs Bipolar Junction Transistors, and light emitters/detectors. — F.


242. Advanced Nanostructured Devices (3)  Lecture—3 hours. Prerequisite: courses 130A and 140A. Physics of nano-structured materials and device operation. Overview of new devices enabled by nanotechnology, fabrication and characterization methods; applications of nano-structures and devices. Offered in alternate years. — F.

244A. Design of Microelectromechanical Systems (MEMS) (3)  Lecture—3 hours. Prerequisite: course 140A, 140B or consent of instructor. Theory and practice of MEMS design. Micromechanical fundamentals, CAD tools, and case studies. A MEMS design project will be completed. The designs will be fabricated in a commercial foundry and tested in course 244B. Offered in alternate years. — F.

244B. Microsieves (4)  Lecture/discussion—4 hours. Introduction to the theory and practice of microsieves at the microscale. Scale effects, surface tension, micromechanical mechanics, micromechanical properties, inter-molecular interactions and micro tribology. [Same course as Biomedical Engineering 168B.] — F.

245. Micro- and Nano-Technology in Life Sciences (4)  Lecture/discussion—4 hours. Prerequisite: graduate standing or consent of instructor. Survey of biomedi
cal devices and materials, nanobiotechnology, and biological perspectives; micro-/nano-fabrication and characterization techniques; surface chemistry and mass transfer; essential biological processes and models; properties and devices to merge aforementioned themes in a multidisciplinary project. [Same course as Chemical Engineering 245 and Materials Science and Engineering 243.] — S.

246. Advanced Projects in IC Fabrication (3)  Discussion—1 hour; laboratory—6 hours. Prerequisite: course 146B. Individualized projects in the fab
cration of analog or digital integrated circuits. Offered in alternate years. — W.

247. Advanced Semiconductor Devices (4)  Lecture—3 hours; prerequisite: graduate standing in Engineering. Semiconductor devices, including MOSFETs, heterojunction transistors, light-emitting diodes, lasers, sensors, detectors, power and high-voltage transistors, MEMS resonators, organic semiconductors and photovoltaics. All material is from recent literature, encouraging students to utilize search methods and critically assess the latest research. Offered in alternate years. — S.

248. Photovoltaics and Solar Cells (3)  Lecture—3 hours. Prerequisite: course 140B or equivalent, or consent of instructor. Physics and application of photovoltaics and solar cells, including design, fabrication and characterization of solid-state solar cells. Mono and multijunction Si solar cells, thin-film technologies, heterojunction and organic-semiconductor technologies. Collectors, electrical inverters and infrastructures issues. Challenges and concerns. [Same course as Engineering-Material Science 246.] Offered in alternate years. — W.

249. Nanofabrication (3)  Lecture—3 hours. Prerequisite: graduate standing in Engineering. Theory and technologies of nanofabri
cation used for producing ICs, electronic devices, optoelectronics, sensors, and micro/nanostructures. Major topics include electron-, photon-, and ion-beams and their interactions with solids, chemical vapor deposition, plasma processing and micromachining. Offered in alternate years. — S.

250. Linear Systems and Signals (4)  Lecture—4 hours. Prerequisite: course 150A. Mathematical description of linear systems; transforms and their inverse inc
duding Laplace and Fourier transforms. State space representation. State feedback and state estimation problems. Theory and applications of digital signal processing. [Same course as Electrical Engineering 102.] — W.


252. Multivariable Control System Design (3)  Lecture—3 hours. Prerequisite: course 250. Modern control system design, theory, and techniques. Topics will include single-loop feedback design, stability, performance design, multivariable control systems; LQG design; Hinfinity design; frequency response methods, and optimization-based design. Offered in alternate years. — W.

254. Optimization (3)  Lecture—3 hours. Prerequisite: Mathematics 22A, knowledge of FORTRAN or C. Modeling optimization problems in engineering design and other applications; optimality conditions; unconstrained optimization (gradient, Newton, conjugate gradient and quasi-Newton methods), duality and Lagrangian relaxation constrained optimization. (Primal method and an introduction to penalty and augmented Lagrangian methods.) Offered in alternate years. — W.

255. Robotic Systems (3)  Lecture—3 hours. Introduction to robotic systems. Mechanical manipulators, kinematics, manipulator positioning and path planning. Dynamics of manipulators. Robot motion planning and control algo
rithm design. Offered in alternate years. — W.

260. Random Signals and Noise (4)  Lecture—3 hours; discussion—1 hour. Prerequisite: Statistics 120, course 150A; course 250 recommended. Random processes as probabilistic models for signals and noise. Review of probability, random variables, and expectation. Study of correlation func
tion and spectral density, ergodicity and duality between time averages and expected values, filters and optimal signal estimation. Applications. — W.

261. Signal Processing for Communications (4)  Lecture—4 hours. Prerequisite: course 165, 260 or consent of instructor. Signal processing in wireless and wireline communication systems. Realization, optimiza
tion and distortion of wireless and wireline channels. Channel equalization and maximum likelihood sequence estimation. Channel precoding and pre
equalization. OFDM and transmit diversity. Array processing. Offered in alternate years. — S.

262. Multi-Access Communications Theory (4)  Lecture—3 hours; project. Prerequisite: Statistics 120 or equivalent; course 173A or Engineering Com
cputer Science 152A. Maximum stable throughput of Poisson collision channels. Classic collision resolu

tion and maximum likelihood estimation of hidden Markov models, Viterbi algorithm. Adaptive filtering algo
rithms, properties and applications. Offered in alternate years. — S.

264. Estimation and Detection of Signals in Noise (4)  Lecture—3 hours; discussion—1 hour. Prerequisite: course 260. Introduction to parameter estimation and detections of signals in noise. Bayes and Ney
dman-Pearson likelihood-ratio tests for signal detec
tion. Maximum-likelihood parameter estimation. Detection of known and Gaussian signals in white or colored noise. Applications to communications, radar, signal processing. — W.

265. Principles of Digital Communications (4)  Lecture—4 hours. Prerequisite: courses 165 and 260, or consent of instructor. Introduction to digital communications. Coding for analog sources. Charac
terization of signals and systems. Modulation and demodulation for the additive Gaussian channel. Digital signaling over bandwidth-constrained linear filter channels and other narrowband channels. Spread spectrum signals. — W.
266. Information Theory and Coding (3) Lecture—3 hours. Prerequisite: Statistics 120. Information theory and coding. Measure of information. Redundancy reduction encoding of an information source. Capacity of a communication channel, error-free communications. Offered in alternate years. —S.

267. Mobile Communications (4) Lecture—3 hours. Prerequisite: courses 260 and 265 (can be taken concurrently). Time-varying multi-path fading channel models and receiver performance in fading channels; multiple access techniques and multiple access receivers design and performance; optimum design for the capacity of wireless channels. Offered in alternate years. —W.

269A. Error Correcting Codes I (3) Lecture—3 hours. Prerequisite: Mathematics 22A and course 160. Introduction to the theory and practice of block codes, linear block codes, cyclic codes, decoding algorithms, coding techniques. —F. (F).

269B. Error Correcting Codes II (3) Lecture—3 hours. Prerequisite: course 165 and 269A. Introduction to convolutional codes, turbo codes, trellis and block coded modulation codes, soft-decision decoding algorithms, the Viterbi algorithm, reliability-based decoding, trellis-based decoding and message decoding. Offered in alternate years. —S. (S.)

270. Computer Architecture (3) Lecture—3 hours. Prerequisite: course 170 or Computer Science Engineering 154B. Introduction to modern techniques for high-performance single- and multiple processor systems. Topics include advanced pipeline design, advanced memory hierarchy design, optimizing pipeline and memory use, and memory and I/O processor design. Case studies of recent single and multiple processor systems. —F. (F).

272. High-Performance Computer Architecture (4) Lecture—4 hours. Prerequisite: course 270 or Computer Science Engineering 201A. Designing and analysis of high performance computer architecture with emphasis on vector processing, on-chip interconnect networks, chip-level multiprocessing, memory and storage subsystem design and impact of technological advancements on computer architecture. Offered in alternate years. —S. (S.)

273. Networking Architecture and Resource Management (4) Lecture—3 hours; project. Prerequisite: course 173A or Computer Science and Engineering 152A. Pass One and Pass Two open to Graduate Students in Computer Science and Electrical and Computer Engineering only. Concepts and design principles of computer networks. Network architectures, protocol mechanisms and implementation principles (transport/network layers), network algorithms, router mechanisms, design requirements of applications, network simulation, modeling and performance analysis. Same course as Computer Science Engineering 258A. —W. (W.)

274. Internet Measurements, Modeling and Analysis (4) Lecture—3 hours; project. Prerequisite: Computer Science Engineering 252 or course 273. Advanced topics in the derivations of network measurements, modeling, and statistical inference. Applications to Internet engineering, routing optimization, load balancing, traffic engineering, fault tolerance, anomaly detection, and network security. Individual project requirement. Offered in alternate years. —S. (S.)

276. Fault-Tolerant Computer Systems: Design and Implementation (3) Lecture—3 hours. Prerequisite: courses 170, 180A. Introduces fault-tolerant digital system theory and practice. Covers recent and classic fault-tolerant techniques based on hardware redundancy, time redundancy, information redundancy, and software redundancy. Examines hardware and software reliability analysis, and example fault-tolerant designs. Not open for credit to students who have completed course 276A. Offered in alternate years. —W. (W.)

277. Graphics Architecture (3) Lecture—3 hours. Prerequisite: Computer Science Engineering 154B or course 170, Computer Science Engineering 175. Design and analysis of the architecture of computer graphics systems. Topics include the graphics pipeline with a concentration on hardware techniques and algorithms, exploiting parallelism in graphics, and recent studies of noteworthy and modern graphics architectures. Offered in alternate years. —W. (W.)

278. Computer Arithmetic for Digital Implementation (3) Lecture—3 hours. Prerequisite: courses 170, 180A. The design and implementation of computer arithmetic logic units are studied with particular emphasis on high-speed performance requirements. Addition (subtraction), multiplication and division operations are covered, and fixed and floating-point representations are examined. Offered in alternate years. —S. (S.)

281. VLSI Digital Signal Processing (4) Lecture—3 hours; project. Prerequisite: courses 150B, 170, 180A or consent of instructor. Digital signal processors, building blocks, and algorithms. Design and implementation of processor algorithms, architectures, control, functional units, and circuit topologies for increased performance and reduced circuit size and power dissipation. Offered in alternate years. —W. (W.)

282. Hardware Software Codesign (3) Lecture—2 hours; discussion—1 hour. Prerequisite: course 170. Design and implementation of embedded systems; modeling and performance estimation; hardware/software partitioning; co-simulation; design reuse; platform-based design; reconfigurable computing. —S. (S.)

283. Advanced Design Verification of Digital Systems (4) Lecture—3 hours; project. Prerequisite: courses 170 and 180A. Design verification techniques for digital systems; simulation-based design verification techniques, formal verification techniques, including equivalence checking, model checking, and theorem proving; timing analysis and verification; application of design certification techniques to microprocessor circuits. Offered in alternate years. —W. (W.)

284. Design and Optimization of Embedded Computing Systems (4) Lecture—4 hours. Prerequisite: courses 170 and 180B, or consent of instructor. Computer Science Engineering 122A recommended. Introduction to design and optimization of digital computing systems for embedded applications. Topics include combinatorial optimization techniques, performance analysis, energy optimization in embedded systems, compilation and architecture-specific mapping, programmable and reconfigurable platforms; design automation and algorithmic design for system process. Offered in alternate years. —W. (W.)

286. Introduction to Digital System Testing (3) Lecture—3 hours. Prerequisite: course 180A. Statistical tests are reviewed, and current state-of-the-art techniques used to diagnose faults in both combinational and sequential circuits. Topics include path sensitization procedures, Boolean difference, D-algorithm random test generation, test generation, and an analysis of the effects of intermittent faults. Not open for credit to students who have completed course 276A. Offered in alternate years. —W. (W.)

289A. Special Topics in Electrical and Computer Engineering: Computer Science (1-5) Lecture/laboratory—1-5 units. Prerequisite: consent of instructor. Special topic in Computer Science. May be repeated for credit when topic differs. —F, W, S. (F, W, S.)

289B. Special Topics in Electrical and Computer Engineering: Programming Systems (1-5) Lecture/laboratory—1-5 units. Prerequisite: consent of instructor. Special topic in Programming Systems. May be repeated for credit when topic differs. —F, W, S. (F, W, S.)

289C. Special Topics in Electrical and Computer Engineering: Digital Systems (1-5) Lecture/laboratory—1-5 units. Prerequisite: consent of instructor. Special topic in Digital Systems. May be repeated for credit when topic differs. —F, W, S. (F, W, S.)

289D. Special Topics in Electrical and Computer Engineering: Digital Communication (1-5) Lecture/laboratory—1-5 units. Prerequisite: consent of instructor. Special topic in Digital Communication. May be repeated for credit when topic differs. —F, W, S. (F, W, S.)

289E. Special Topics in Electrical and Computer Engineering: Robotics (1-5) Lecture/laboratory—1-5 units. Prerequisite: consent of instructor. Special topic in Robotics. May be repeated for credit when topic differs. —F, W, S. (F, W, S.)

289F. Special Topics in Electrical and Computer Engineering: Control Systems (1-5) Lecture/laboratory—1-5 units. Prerequisite: consent of instructor. Special topic in Control Systems. May be repeated for credit when topic differs. —F, W, S. (F, W, S.)

289G. Special Topics in Electrical and Computer Engineering: Image Processing (1-5) Lecture/laboratory—1-5 units. Prerequisite: consent of instructor. Special topic in Image Processing. May be repeated for credit when topic differs. —F, W, S. (F, W, S.)

289H. Special Topics in Electrical and Computer Engineering: High Frequency Phenomena and Devices (1-5) Lecture/laboratory—1-5 units. Prerequisite: consent of instructor. Special topic in High Frequency Phenomena and Devices. May be repeated for credit when topic differs. —F, W, S. (F, W, S.)

289I. Special Topics in Electrical and Computer Engineering: Solid-State Devices and Physical Electronics (1-5) Lecture/laboratory—1-5 units. Prerequisite: consent of instructor. Special topic in Solid-State Devices and Physical Electronics. May be repeated for credit when topic differs. —F, W, S. (F, W, S.)
Engineering: Materials Science and Engineering

289M. Special Topics in Electrical and Computer Engineering: Systems Theory (1-5)
Lecture/laboratory—1.5 units. Prerequisite: consent of instructor. Special topic in Systems Theory. May be repeated for credit when topics differ. —F, W, S. (F, W, S.)

289N. Special Topics in Electrical and Computer Engineering: Active and Passive Circuits (1-5)
Lecture/laboratory—1.5 units. Prerequisite: consent of instructor. Special topic in Active and Passive Circuits. May be repeated for credit when topics differ. —F, W, S. (F, W, S.)

289O. Special Topics in Electrical and Computer Engineering: Integrated Circuits (1-5)
Lecture/laboratory—1.5 units. Prerequisite: consent of instructor. Special topic in Integrated Circuits. May be repeated for credit when topics differ. —F, W, S. (F, W, S.)

289P. Special Topics in Electrical and Computer Engineering: Computer Software (1-5)
Lecture/laboratory—1.5 units. Prerequisite: consent of instructor. Special topic in Computer Software. May be repeated for credit when topics differ. —F, W, S. (F, W, S.)

289Q. Special Topics in Electrical and Computer Engineering: Computer Engineering (1-5)
Lecture/laboratory—1.5 units. Prerequisite: consent of instructor. Special topic in Computer Engineering. May be repeated for credit when topics differ. —F, W, S. (F, W, S.)

289R. Special Topics in Electrical and Computer Engineering: Microprocessing (1-5)
Lecture/laboratory—1.5 units. Prerequisite: consent of instructor. Special topic in Microprocessing. May be repeated for credit when topics differ. —F, W, S. (F, W, S.)

289S. Special Topics in Electrical and Computer Engineering: Electronics (1-5)
Lecture/laboratory—1.5 units. Prerequisite: consent of instructor. Special topic in Electronics. May be repeated for credit when topics differ. —F, W, S. (F, W, S.)

289T. Special Topics in Electrical and Computer Engineering: Electromagnetics (1-5)
Lecture/laboratory—1.5 units. Prerequisite: consent of instructor. Special topic in Electromagnetics. May be repeated for credit when topics differ. —F, W, S. (F, W, S.)

289U. Special Topics in Electrical and Computer Engineering: Optoelectronics (1-5)
Lecture/laboratory—1.5 units. Prerequisite: consent of instructor. Special topic in Optoelectronics. May be repeated for credit when topics differ. —F, W, S. (F, W, S.)

289V. Special Topics in Electrical and Computer Engineering: Computer Networks (1-5)
Lecture/laboratory—1.5 units. Prerequisite: consent of instructor. Special topic in Computer Networks. May be repeated for credit when topics differ. —F, W, S. (F, W, S.)

290. Seminar in Electrical and Computer Engineering (1)
Seminar—1 hour. Discussion and presentation of current research and development in Electrical and Computer Engineering. May be repeated for credit. (S/U grading only.) —F, W, S. (F, W, S.)

290C. Graduate Research Group Conference in Electrical and Computer Engineering (1)
Discussion—1 hour. Prerequisite: consent of instructor. Research problems, progress, and techniques in electrical and computer engineering. May be repeated for credit. (S/U grading only.) —F, W, S. (F, W, S.)

291. Solid-State Circuit Research Laboratory Seminar (1)
Seminar—1 hour. Prerequisite: graduate standing. Lectures on solid-state circuit and system design by various visiting experts in the field. May be repeated for credit. (S/U grading only.) —S. (F, S, S.)

292. Seminar in Solid-State Technology (1)
Seminar—1 hour. Prerequisite: graduate standing. Lectures on solid-state technology by various visiting experts in the field. May be repeated for credit. (S/U grading only.) —F, W, S. (F, W, S.)

293. Computer Engineering Research Seminar (1)
Seminar—1 hour. Prerequisite: graduate standing. Seminar on topics in computer engineering. May be repeated for credit up to four times. (S/U grading only.) —F, W, S. (F, W, S.)

294. Communications, Signal and Image Processing Seminar (1)
Seminar—1 hour. Prerequisite: graduate standing. Seminar on communications, signal and image processing, video engineering and computer vision. May be repeated for credit. (S/U grading only.) —F, W, S. (F, W, S.)

295. Systems, Control and Robotics Seminar (1)
Seminar—1 hour. Prerequisite: graduate standing. Seminar on current research in systems and control by faculty and visiting experts. Technical presentations and lectures on recent topics in robotics research and robotics technology. May be repeated for credit. (S/U grading only.) —F, W, S. (F, W, S.)

296. Photonics Research Seminar (1)
Seminar—1 hour. Prerequisite: graduate standing. Seminar on photonics and related areas by faculty and visiting experts. May be repeated for credit. (S/U grading only.) —F, W, S. (F, W, S.)

298. Group Study (1-5)
Prerequisite: consent of instructor. (S/U grading only.)

299. Research (1-12)
(S/U grading only.)

Professional

300. The Teaching of Electrical Engineering (1)
Discussion—1 hour. Prerequisite: meet qualifications for teaching assistant and/or associate-in in Electrical Engineering. Participation as a teaching assistant or associate-in in a designated engineering course. Methods of leading discussion groups or laboratory sections, work with students, use of laboratory equipment, and grading laboratory reports. May be repeated for credit. (S/U grading only.) —F, W, S. (F, W, S.)

396. Teaching Assistant Training Practicum (1-6)
Prerequisite: graduate standing. May be repeated for credit. (S/U grading only.) —F, W, S. (F, W, S.)

Materials Science and Engineering Undergraduate Program
The Materials Science and Engineering program is accredited by the Engineering Accreditation Commission of ABET; see http://www.abet.org.

Materials science and engineering is directed toward understanding the structure, properties, and processing of materials. Society demands new and improved materials with capabilities far superior to common metals, polymers, and ceramics. New materials are needed for high-speed transportation systems, surgical and dental implants, new generations of power plants, renewable energy sources, and solid-state electronic and photonics devices in...