Electrical Engineering and Computer Sciences

The Department of Electrical Engineering and Computer Sciences offers three graduate programs in Electrical Engineering: the Master of Engineering (MEng) in Electrical Engineering and Computer Sciences, the Master of Science (MS), and the Doctor of Philosophy (PhD).

Master of Engineering (MEng)

The Master of Engineering (MEng) in Electrical Engineering & Computer Sciences, first offered by the EECS Department in the 2011-2012 academic year, is a professional master's with a larger tuition than our other programs and is for students who plan to join the engineering profession immediately following graduation. This accelerated program is designed to train professional engineering leaders who understand the technical, economic, and social issues around technology. The interdisciplinary experience spans one academic year and includes three major components: (1) an area of technical concentration, (2) courses in leadership skills, and (3) a rigorous capstone project experience.

Master of Science (MS)

The Master of Science (MS) emphasizes research preparation and experience and, for most students, provides an opportunity to lay the groundwork for pursuing a PhD.

Doctor of Philosophy (PhD)

The Berkeley PhD in EECS combines coursework and original research with some of the finest EECS faculty in the US, allowing students to prepare for careers in academia or industry. Our alumni (http://www.eecs.berkeley.edu/alumni/distinguished.shtml/) have gone on to hold amazing positions around the world.

Admission to the University

Applying for Graduate Admission

Thank you for considering UC Berkeley for graduate study! UC Berkeley offers more than 120 graduate programs representing the breadth and depth of interdisciplinary scholarship. The Graduate Division hosts a complete list (https://grad.berkeley.edu/admissions/choosing-your-program/list/) of graduate academic programs, departments, degrees offered, and application deadlines can be found on the Graduate Division website.

Prospective students must submit an online application to be considered for admission, in addition to any supplemental materials specific to the program for which they are applying. The online application and steps to take to apply can be found on the Graduate Division website (https://grad.berkeley.edu/admissions/steps-to-apply/).

Admission Requirements

The minimum graduate admission requirements are:

1. A bachelor's degree or recognized equivalent from an accredited institution;
2. A satisfactory scholastic average, usually a minimum grade-point average (GPA) of 3.0 (B) on a 4.0 scale; and
3. Enough undergraduate training to do graduate work in your chosen field.

For a list of requirements to complete your graduate application, please see the Graduate Division's Admissions Requirements page (https://grad.berkeley.edu/admissions/steps-to-apply/requirements/). It is also important to check with the program or department of interest, as they may have additional requirements specific to their program of study and degree. Department contact information can be found here (https://guide.berkeley.edu/graduate/degree-programs/).

Where to apply?

Visit the Berkeley Graduate Division application page (http://grad.berkeley.edu/admissions/apply/).

Admission to the MS/PhD Program

The following items are required for admission to the Berkeley EECS MS/PhD program in addition to the University's general graduate admission requirements:

1. **Statement of Purpose:** Why are you applying to this program? What do you hope to accomplish during this degree program? What do you want to do afterwards, and how will this degree help you to achieve your goals?
2. **Personal History Statement:** What past experiences made you decide to go into this field? How will your personal history help you succeed in this program and reach your future goals?
3. **GPA:** If you attended a university outside of the USA, please leave the GPA section blank.
4. **Resume:** Please also include a full resume/CV listing your experience and education.

Complete the online UC Berkeley graduate application:

1. Start your application through this link (http://www.grad.berkeley.edu/) and fill in each relevant page.
2. Upload the materials above, and send the recommender links several weeks prior to the application deadline to give your recommenders time to submit their letters.

Normative Time Requirements

Total Normative Time

Normative time in the EECS department is between 5.5-6 years for the doctoral program.

Time to Advancement

Curriculum

The faculty of the College of Engineering recommends a minimum number of courses taken while in graduate standing. The total minimum is 24 units of coursework, taken for a letter grade and not including courses numbered 297, 298, 299, 301, 302, 375 and 602.

Approved study list per student's research interests to include:

12 200-level units in one major field within EECS, with a 3.5 GPA	
6 100 or 200-level units in one minor field within EECS, with a 3.0 GPA and at least one 200-level course	

Students can choose between Plan 1 or Plan 2. Plan 1 (Outside Minor) - a total of at least six units; at least one graduate level course from a field outside EECS; minimum 3.0 grade point average; Plan 2 (Electives) - two courses consisting of one free elective course from any department, any area except for the major, and one outside EECS course that is not in the major and not listed as EECS; at least 3+ units each; minimum 3.0 grade point average. Note: students who began the Ph.D. program in Fall 2021 onwards must follow Plan 2.

Possible courses include:

Major area:		
EL ENG 210	Applied Electromagnetic Theory	3
EL ENG 213A	Power Electronics	4
EL ENG C213	X-rays and Extreme Ultraviolet Radiation	3
EL ENG 218A	Introduction to Optical Engineering	4
EL ENG 219A	Course Not Available	4
EL ENG 219B	Logic Synthesis	4
EL ENG C220A	Advanced Control Systems I	3
EL ENG C220B	Experiential Advanced Control Design I	3
EL ENG C220C	Experiential Advanced Control Design II	3
EL ENG C220D	Input/Output Methods for Compositional System Analysis	2
EL ENG 221A	Linear System Theory	4
EL ENG 222	Nonlinear Systems--Analysis, Stability and Control	3
EL ENG C222	Nonlinear Systems	3
EL ENG 223	Stochastic Systems: Estimation and Control	3
EL ENG 224A	Digital Communications	4
EL ENG 224B	Fundamentals of Wireless Communication	3
EL ENG 225D	Audio Signal Processing in Humans and Machines	3
EL ENG C225E	Principles of Magnetic Resonance Imaging	4
EL ENG 226A	Random Processes in Systems	4
EL ENG 226B	Applications of Stochastic Process Theory	2
EL ENG 227BT	Convex Optimization	4
EL ENG C227C	Convex Optimization and Approximation	3
EL ENG C227T	Introduction to Convex Optimization	4
EL ENG 228A	High Speed Communications Networks	3
EL ENG 229A	Information Theory and Coding	3
EL ENG 229B	Error Control Coding	3
EL ENG 230A	Integrated-Circuit Devices	4
EL ENG 230B	Solid State Devices	4
EL ENG 230C	Solid State Electronics	3
EL ENG W230A	Integrated-Circuit Devices	4
EL ENG W230B	Solid State Devices	4
EL ENG 232	Lightwave Devices	4
EL ENG C235	Nanoscale Fabrication	4
EL ENG 236A	Quantum and Optical Electronics	3
EL ENG C239	Partially Ionized Plasmas	3
EL ENG 240A	Analog Integrated Circuits	4
EL ENG 240B	Advanced Analog Integrated Circuits	4
EL ENG 240C	Analysis and Design of VLSI Analog-Digital Interface Integrated Circuits	3
EL ENG W240A	Analog Integrated Circuits	4
EL ENG W240B	Advanced Analog Integrated Circuits	3
EL ENG W240C	Analysis and Design of VLSI Analog-Digital Interface Integrated Circuits	3
EL ENG 241B	Advanced Digital Integrated Circuits	3
EL ENG W241A	Introduction to Digital Integrated Circuits	4
EL ENG W241B	Advanced Digital Integrated Circuits	3
EL ENG 242A	Integrated Circuits for Communications	4
EL ENG 242B	Advanced Integrated Circuits for Communications	3
EL ENG W242A	Integrated Circuits for Communications	4
EL ENG W242B	Advanced Integrated Circuits for Communications	3
EL ENG 243	Advanced IC Processing and Layout	3
EL ENG 244	Fundamental Algorithms for Systems Modeling, Analysis, and Optimization	4
EL ENG W244	Fundamental Algorithms for System Modeling, Analysis, and Optimization	4
EL ENG C246	Parametric and Optimal Design of MEMS	3
EL ENG 247A	Introduction to Microelectromechanical Systems (MEMS)	3
EL ENG C247B	Introduction to MEMS Design	4
EL ENG W247B	Introduction to MEMS Design	4
EL ENG 248C	Numerical Modeling and Analysis: Nonlinear Systems and Noise	4
EL ENG C249A	Introduction to Embedded Systems	4
EL ENG C249B	Course Not Available	4
EL ENG C261	Medical Imaging Signals and Systems	4
EL ENG 290	Advanced Topics in Electrical Engineering	1-4
EL ENG 290A	Advanced Topics in Electrical Engineering: Advanced Topics in Computer-Aided Design	1-3
EL ENG 290B	Advanced Topics in Electrical Engineering: Advanced Topics in Solid State Devices	1-3
EL ENG 290C	Advanced Topics in Electrical Engineering: Advanced Topics in Circuit Design	1-3
EL ENG 290D	Advanced Topics in Electrical Engineering: Advanced Topics in Semiconductor Technology	1-3
EL ENG 290F	Advanced Topics in Electrical Engineering: Advanced Topics in Photonics	1-3
EL ENG 290G	Advanced Topics in Electrical Engineering: Advanced Topics in Mems, Microsensors, and Microactuators	1-3
EL ENG 290N	Advanced Topics in Electrical Engineering: Advanced Topics in System Theory	1-3
EL ENG 290O	Advanced Topics in Electrical Engineering: Advanced Topics in Control	1-3
EL ENG 290P	Advanced Topics in Electrical Engineering: Advanced Topics in Bioelectronics	1-3
EL ENG 290Q	Advanced Topics in Electrical Engineering: Advanced Topics in Communication Networks	1-3
EL ENG 290S	Advanced Topics in Electrical Engineering: Advanced Topics in Communications and Information Theory	1-3
EL ENG 290T	Advanced Topics in Electrical Engineering: Advanced Topics in Signal Processing	1-3
EL ENG 290Y	Advanced Topics in Electrical Engineering: Organic Materials in Electronics	3
EL ENG W290C	Advanced Topics in Circuit Design	3

EL ENG C291	Control and Optimization of Distributed Parameters Systems	3
EL ENG C291E	Hybrid Systems and Intelligent Control	3
EL ENG 297	Field Studies in Electrical Engineering	12
EL ENG 298	Group Studies, Seminars, or Group Research	1-4
EL ENG 299	Individual Research	1-12
EL ENG 375	Teaching Techniques for Electrical Engineering	2
EL ENG 602	Individual Study for Doctoral Students	1-8
COMPSCI C200A	Principles and Techniques of Data Science	4
COMPSCI C249A	Introduction to Embedded Systems	4
COMPSCI 250	VLSI Systems Design	4
COMPSCI 252A	Graduate Computer Architecture	4
COMPSCI 260A	User Interface Design and Development	4
COMPSCI 260B	Human-Computer Interaction Research	3
COMPSCI 261	Security in Computer Systems	3
COMPSCI 261N	Internet and Network Security	4
COMPSCI 262A	Advanced Topics in Computer Systems	4
COMPSCI 262B	Advanced Topics in Computer Systems	3
COMPSCI 263	Design of Programming Languages	3
COMPSCI 264	Implementation of Programming Languages	4
COMPSCI 265	Compiler Optimization and Code Generation	3
COMPSCI C267	Applications of Parallel Computers	3
COMPSCI W267	Course Not Available	3
COMPSCI 268	Computer Networks	3
COMPSCI 270	Combinatorial Algorithms and Data Structures	3
COMPSCI 271	Randomness and Computation	3
COMPSCI 273	Course Not Available	3
COMPSCI 274	Computational Geometry	3
COMPSCI 276	Cryptography	3
COMPSCI C280	Computer Vision	3
COMPSCI C281A	Statistical Learning Theory	3
COMPSCI C281B	Advanced Topics in Learning and Decision Making	3
COMPSCI 282A	Designing, Visualizing and Understanding Deep Neural Networks	4
COMPSCI 284A	Foundations of Computer Graphics	4
COMPSCI 284B	Advanced Computer Graphics Algorithms and Techniques	4
COMPSCI 285	Deep Reinforcement Learning, Decision Making, and Control	3
COMPSCI 286A	Course Not Available	4
COMPSCI 286B	Course Not Available	3
COMPSCI 287	Advanced Robotics	3
COMPSCI 287H	Algorithmic Human-Robot Interaction	4
COMPSCI 288	Natural Language Processing	4
COMPSCI 289A	Introduction to Machine Learning	4
COMPSCI 294	Special Topics	1-4
Upper division EECS Courses (Can be used for Inside Minor)		
EL ENG 105	Microelectronic Devices and Circuits	4
EL ENG C106A	Introduction to Robotics	4
EL ENG C106B	Robotic Manipulation and Interaction	4
EL ENG 113	Power Electronics	4
EL ENG 117	Electromagnetic Fields and Waves	4
EL ENG 118	Introduction to Optical Engineering	4
EL ENG 120	Signals and Systems	4
EL ENG 121	Introduction to Digital Communication Systems	4
EL ENG 122	Introduction to Communication Networks	4
EL ENG 123	Digital Signal Processing	4
EL ENG 126	Probability and Random Processes	4
EL ENG C128	Feedback Control Systems	4
EL ENG 130	Integrated-Circuit Devices	4
EL ENG 134	Fundamentals of Photovoltaic Devices	4
EL ENG 137A	Introduction to Electric Power Systems	4
EL ENG 137B	Introduction to Electric Power Systems	4
EL ENG 140	Linear Integrated Circuits	4
EL ENG 142	Integrated Circuits for Communications	4
EL ENG 143	Microfabrication Technology	4
EL ENG 144	Fundamental Algorithms for Systems Modeling, Analysis, and Optimization	4
EL ENG C145B	Medical Imaging Signals and Systems	4
EL ENG C145L	Introductory Electronic Transducers Laboratory	3
EL ENG C145M	Introductory Microcomputer Interfacing Laboratory	3
EL ENG C145O	Laboratory in the Mechanics of Organisms	3
EL ENG 146L	Application Specific Integrated Circuits Laboratory	2
EL ENG 147	Introduction to Microelectromechanical Systems (MEMS)	3
EL ENG 192	Mechatronic Design Laboratory	4
COMPSCI 146L	Course Not Available	2
COMPSCI 152	Computer Architecture and Engineering	4
COMPSCI 160	User Interface Design and Development	4
COMPSCI 161	Computer Security	4
COMPSCI 162	Operating Systems and System Programming	4
COMPSCI 164	Programming Languages and Compilers	4
COMPSCI 168	Introduction to the Internet: Architecture and Protocols	4
COMPSCI 169	Course Not Available	4
COMPSCI 169A	Introduction to Software Engineering	4
COMPSCI 169L	Software Engineering Team Project	2
COMPSCI W169A	Course Not Available	3
COMPSCI 170	Efficient Algorithms and Intractable Problems	4
COMPSCI 171	Cryptography	4
COMPSCI 172	Computability and Complexity	4
COMPSCI 174	Combinatorics and Discrete Probability	4
COMPSCI 176	Algorithms for Computational Biology	4
COMPSCI 182	Course Not Available	4
COMPSCI 184	Foundations of Computer Graphics	4
COMPSCI 186	Introduction to Database Systems	4
COMPSCI W186	Course Not Available	4
COMPSCI 188	Introduction to Artificial Intelligence	4
COMPSCI 189	Introduction to Machine Learning	4
COMPSCI C191	Introduction to Quantum Computing	3

Preliminary Exams

The EECS preliminary requirement consists of two components:

Oral Examination

The oral exam serves an advisory role in a student's graduate studies, providing official feedback from an exam committee of faculty members.

Students must be able to demonstrate an integrated grasp of the exam area's body of knowledge in an unstructured framework. Students must pass the oral portion of the preliminary exam within their first two attempts. A third attempt is possible with a petition of support from the student's faculty adviser and final approval by the prelim committee chair. Failure to pass the oral portion of the preliminary exam will result in the student being ineligible to complete the PhD program. The examining committee awards a score in the range of 0-10. The minimum passing score is 6.0.

Breadth Courses

The prelim breadth courses ensure that students have exposure to areas outside their concentration.

EE students are expected to complete two courses of at least three units each in two areas of EECS outside their prelim oral exam area. These courses must be graduate or advanced undergraduate courses, and students must receive a grade of A- or better.

Qualifying Examination

The qualifying examination is an important checkpoint, meant to show that a student is on a promising research track toward the PhD. It is a University examination, administered by the Graduate Council, with the specific purpose of demonstrating that "the student is clearly an expert in those areas of the discipline that have been specified for the examination, and that he or she can, in all likelihood, design and produce an acceptable dissertation." Despite such rigid criteria, faculty examiners recognize that the level of expertise expected is that appropriate for a third year graduate student who may be only in the early stages of a research project.

The EECS department offers the qualifying exam in two formats, A or B. Students may choose the exam type of their choice after consultation with their advisor.

Format A

1. Students prepare a write-up and presentation, summarizing a specific research area, preferably the one in which they intend to do their dissertation work. Their summary surveys that area and describes open and interesting research problems.
2. They describe why they chose these problems and indicate what direction their research may take in the future.
3. They prepare to display expertise on both the topic presented and on any related material that the committee thinks is relevant.
4. The student should talk (at least briefly) about any research progress to date (e.g., MS project, PhD research, or class project). Some evidence of their ability to do research is expected.
5. The committee shall evaluate students on the basis of their comprehension of the fundamental facts and principles that apply within their research area and the student's ability to think incisively and critically about the theoretical and practical aspects of this field.
6. Students must demonstrate command of the content and the ability to design and produce an acceptable dissertation.

Format B

This option includes the presentation and defense of a thesis proposal in addition to the requirements of option A. It will include a summary of research to date and plans for future work (or at least the next stage thereof). The committee shall not only evaluate the student's thesis proposal and his/her progress to date, but shall also evaluate according to option A. As in option A, the student should prepare a single document and presentation, but in this case, additional emphasis must be placed on research completed to date and plans for the remainder of the dissertation research.

Thesis Proposal Defense

Students not presenting a satisfactory thesis proposal defense, either because they took option A for the QE, or because the material presented in an option B exam was not deemed a satisfactory proposal defense (although it may have sufficed to pass the QE), must write up and present a thesis proposal, which should include a summary of the research to date and plans for the remainder of the dissertation research. They should be prepared to discuss background and related areas, but the focus of the proposal should be on the progress made so far, and detailed plans for completing the thesis. The standard for continuing with PhD research is that the proposal has sufficient merit to lead to a satisfactory dissertation. Another purpose of this presentation is for faculty to provide feedback on the quality of work to date. For this step, the committee should consist of at least three members from EECS familiar with the research area, preferably including those on the dissertation committee.

Normative Time in Candidacy

Advancement to Candidacy

Students must file the advancement form online through CalCentral no later than the end of the semester following the one in which the qualifying exam was passed. In approving this application, Graduate Division approves the dissertation committee and will send a certificate of candidacy.

Students in the EECS department are required to be advanced to candidacy at least two semesters before they are eligible to graduate. Once a student is advanced to candidacy, candidacy is valid for five years. For the first three years, non-resident tuition may be waived, if applicable.

Dissertation Talk

As part of the requirements for the doctoral degree, students must give a public talk on the research covered by their dissertation. The dissertation talk should be given a few months before the signing of the final submission of the dissertation. It must be given before the final submission of the dissertation. The talk should cover all the major components of the dissertation in a substantial manner; in particular, the dissertation talk should not omit topics that will appear in the dissertation but are incomplete at the time of the talk.

The dissertation talk is to be attended by the whole dissertation committee, or, if this is not possible, by at least a majority of the members. Attendance at this talk is part of the committee's responsibility. It is, however, the responsibility of the student to schedule a time for the talk that is convenient for members of the committee.

Required Professional Development

Graduate Student Instructor Teaching Requirement

The department requires all PhD candidates to serve as graduate student instructors (GSIs) within the EECS department. The GSI teaching requirement not only helps to develop a student's communication skills, but it also makes a great contribution to the department's academic community. Students must fulfill this requirement by working as a GSI (excluding EL ENG 375, or COMPSCI 375) for a total of 30 hours

minimum prior to graduation. At least 20 of those hours must be for an EE or CS undergraduate course. In addition, students must earn a Satisfactory grade in the mandatory pedagogy course to complete the GSI teaching requirement.

Unit requirements

A minimum of 24 units is required.

Curriculum

All courses must be taken for a letter grade, except courses numbered 299, which are only offered for *S/U* credit.

Students must maintain a minimum cumulative GPA of 3.0. No credit will be given for courses in which the student earns a grade of D+ or below.

Transfer credit may be awarded for a maximum of 4 semester or 6 quarter units of graduate coursework from another institution.

Plan I

10 units of courses, selected from the 200-series (excluding 298 and 299) in EECS

EL ENG 299	Individual Research	4-10
or COMPSCI 2	Individual Research	

Upper division or graduate courses to reach the minimum of 24 units

Plan II

10 units of courses, selected from the 200-series (excluding 298 and 299) in EECS

EL ENG 299	Individual Research	3-6
or COMPSCI 2	Individual Research	

Upper division or graduate courses to reach the minimum of 24 units

Possible courses include:

EL ENG 210	Applied Electromagnetic Theory	3
EL ENG 213A	Power Electronics	4
EL ENG C213	X-rays and Extreme Ultraviolet Radiation	3
EL ENG 218A	Introduction to Optical Engineering	4
EL ENG 219A	Course Not Available	4
EL ENG 219B	Logic Synthesis	4
EL ENG C220A	Advanced Control Systems I	3
EL ENG C220B	Experiential Advanced Control Design I	3
EL ENG C220C	Experiential Advanced Control Design II	3
EL ENG C220D	Input/Output Methods for Compositional System Analysis	2
EL ENG 221A	Linear System Theory	4
EL ENG 222	Nonlinear Systems--Analysis, Stability and Control	3
EL ENG C222	Nonlinear Systems	3
EL ENG 223	Stochastic Systems: Estimation and Control	3
EL ENG 224A	Digital Communications	4
EL ENG 224B	Fundamentals of Wireless Communication	3
EL ENG 225D	Audio Signal Processing in Humans and Machines	3
EL ENG C225E	Principles of Magnetic Resonance Imaging	4
EL ENG 226A	Random Processes in Systems	4
EL ENG 226B	Applications of Stochastic Process Theory	2
EL ENG 227BT	Convex Optimization	4
EL ENG C227C	Convex Optimization and Approximation	3
EL ENG C227T	Introduction to Convex Optimization	4
EL ENG 228A	High Speed Communications Networks	3
EL ENG 229A	Information Theory and Coding	3
EL ENG 229B	Error Control Coding	3
EL ENG 230A	Integrated-Circuit Devices	4
EL ENG 230B	Solid State Devices	4
EL ENG 230C	Solid State Electronics	3
EL ENG W230A	Integrated-Circuit Devices	4
EL ENG W230B	Solid State Devices	4
EL ENG 232	Lightwave Devices	4
EL ENG C235	Nanoscale Fabrication	4
EL ENG 236A	Quantum and Optical Electronics	3
EL ENG C239	Partially Ionized Plasmas	3
EL ENG 240A	Analog Integrated Circuits	4
EL ENG 240B	Advanced Analog Integrated Circuits	4
EL ENG 240C	Analysis and Design of VLSI Analog-Digital Interface Integrated Circuits	3
EL ENG W240A	Analog Integrated Circuits	4
EL ENG W240B	Advanced Analog Integrated Circuits	3
EL ENG W240C	Analysis and Design of VLSI Analog-Digital Interface Integrated Circuits	3
EL ENG 241B	Advanced Digital Integrated Circuits	3
EL ENG W241A	Introduction to Digital Integrated Circuits	4
EL ENG W241B	Advanced Digital Integrated Circuits	3
EL ENG 242A	Integrated Circuits for Communications	4
EL ENG 242B	Advanced Integrated Circuits for Communications	3
EL ENG W242A	Integrated Circuits for Communications	4
EL ENG W242B	Advanced Integrated Circuits for Communications	3
EL ENG 243	Advanced IC Processing and Layout	3
EL ENG 244	Fundamental Algorithms for Systems Modeling, Analysis, and Optimization	4
EL ENG W244	Fundamental Algorithms for System Modeling, Analysis, and Optimization	4
EL ENG C246	Parametric and Optimal Design of MEMS	3
EL ENG 247A	Introduction to Microelectromechanical Systems (MEMS)	3
EL ENG C247B	Introduction to MEMS Design	4
EL ENG W247B	Introduction to MEMS Design	4
EL ENG 248C	Numerical Modeling and Analysis: Nonlinear Systems and Noise	4
EL ENG C249A	Introduction to Embedded Systems	4
EL ENG C249B	Course Not Available	4
EL ENG C261	Medical Imaging Signals and Systems	4
EL ENG 290	Advanced Topics in Electrical Engineering	1-4
EL ENG C291	Control and Optimization of Distributed Parameters Systems	3
EL ENG C291E	Hybrid Systems and Intelligent Control	3
EECS C206A	Introduction to Robotics	4
EECS C206B	Robotic Manipulation and Interaction	4
EECS 208	Computational Principles for High-dimensional Data Analysis	4
EECS 219C	Formal Methods: Specification, Verification, and Synthesis	3
EECS 225A	Statistical Signal Processing	3

EECS 225B	Digital Image Processing	3
EECS 227AT	Optimization Models in Engineering	4
EECS 251A	Introduction to Digital Design and Integrated Circuits	3
EECS 251B	Advanced Digital Integrated Circuits and Systems	4
EECS 251LA	Introduction to Digital Design and Integrated Circuits Lab	2
EECS 251LB	Introduction to Digital Design and Integrated Circuits Lab	2
EECS 151LB	Field-Programmable Gate Array Laboratory	2
COMPSCI C200A	Principles and Techniques of Data Science	4
COMPSCI C249A	Introduction to Embedded Systems	4
COMPSCI 250	VLSI Systems Design	4
COMPSCI 252A	Graduate Computer Architecture	4
COMPSCI 260A	User Interface Design and Development	4
COMPSCI 260B	Human-Computer Interaction Research	3
COMPSCI 261	Security in Computer Systems	3
COMPSCI 262A	Advanced Topics in Computer Systems	4
COMPSCI 262B	Advanced Topics in Computer Systems	3
COMPSCI 263	Design of Programming Languages	3
COMPSCI 264	Implementation of Programming Languages	4
COMPSCI 265	Compiler Optimization and Code Generation	3
COMPSCI C267	Applications of Parallel Computers	3
COMPSCI 268	Computer Networks	3
COMPSCI 270	Combinatorial Algorithms and Data Structures	3
COMPSCI 271	Randomness and Computation	3
COMPSCI 273	Course Not Available	3
COMPSCI 274	Computational Geometry	3
COMPSCI 276	Cryptography	3
COMPSCI C280	Computer Vision	3
COMPSCI C281A	Statistical Learning Theory	3
COMPSCI C281B	Advanced Topics in Learning and Decision Making	3
COMPSCI 282A	Designing, Visualizing and Understanding Deep Neural Networks	4
COMPSCI 284A	Foundations of Computer Graphics	4
COMPSCI 284B	Advanced Computer Graphics Algorithms and Techniques	4
COMPSCI 285	Deep Reinforcement Learning, Decision Making, and Control	3
COMPSCI 286A	Course Not Available	4
COMPSCI 286B	Course Not Available	3
COMPSCI 287	Advanced Robotics	3
COMPSCI 287H	Algorithmic Human-Robot Interaction	4
COMPSCI 288	Natural Language Processing	4
COMPSCI 289A	Introduction to Machine Learning	4
COMPSCI 294	Special Topics	1-4
Upper division EECS Courses (Can be used for Inside Minor)		
EL ENG 105	Microelectronic Devices and Circuits	4
EL ENG C106A	Introduction to Robotics	4
EL ENG C106B	Robotic Manipulation and Interaction	4
EL ENG 113	Power Electronics	4
EL ENG 117	Electromagnetic Fields and Waves	4
EL ENG 118	Introduction to Optical Engineering	4
EL ENG 120	Signals and Systems	4
EL ENG 121	Introduction to Digital Communication Systems	4
EL ENG 122	Introduction to Communication Networks	4
EL ENG 123	Digital Signal Processing	4
EL ENG 126	Probability and Random Processes	4
EL ENG C128	Feedback Control Systems	4
EL ENG 130	Integrated-Circuit Devices	4
EL ENG 134	Fundamentals of Photovoltaic Devices	4
EL ENG 137A	Introduction to Electric Power Systems	4
EL ENG 137B	Introduction to Electric Power Systems	4
EL ENG 140	Linear Integrated Circuits	4
EL ENG 142	Integrated Circuits for Communications	4
EL ENG 143	Microfabrication Technology	4
EL ENG 144	Fundamental Algorithms for Systems Modeling, Analysis, and Optimization	4
EL ENG C145B	Medical Imaging Signals and Systems	4
EL ENG C145L	Introductory Electronic Transducers Laboratory	3
EL ENG C145M	Introductory Microcomputer Interfacing Laboratory	3
EL ENG 146L	Application Specific Integrated Circuits Laboratory	2
EL ENG 147	Introduction to Microelectromechanical Systems (MEMS)	3
EL ENG 192	Mechatronic Design Laboratory	4
COMPSCI 146L	Course Not Available	2
COMPSCI 152	Computer Architecture and Engineering	4
COMPSCI 160	User Interface Design and Development	4
COMPSCI 161	Computer Security	4
COMPSCI 162	Operating Systems and System Programming	4
COMPSCI 164	Programming Languages and Compilers	4
COMPSCI 168	Introduction to the Internet: Architecture and Protocols	4
COMPSCI 169	Course Not Available	4
COMPSCI 169A	Introduction to Software Engineering	4
COMPSCI 169L	Software Engineering Team Project	2
COMPSCI W169A	Course Not Available	3
COMPSCI 170	Efficient Algorithms and Intractable Problems	4
COMPSCI 171	Cryptography	4
COMPSCI 172	Computability and Complexity	4
COMPSCI 174	Combinatorics and Discrete Probability	4
COMPSCI 176	Algorithms for Computational Biology	4
COMPSCI 182	Course Not Available	4
COMPSCI 184	Foundations of Computer Graphics	4
COMPSCI 186	Introduction to Database Systems	4
COMPSCI W186	Course Not Available	4
COMPSCI 188	Introduction to Artificial Intelligence	4
COMPSCI 189	Introduction to Machine Learning	4
COMPSCI C191	Introduction to Quantum Computing	3
Plus research units for EECS major		
EL ENG 299	Individual Research [1-12]	
Plus research units for CS major		
COMPSCI 299	Individual Research [1-12]	

Advancement to Candidacy

For both Plan I and Plan II, MS students need to complete the departmental Advance to Candidacy form, have their research advisor sign the form, and submit the form to the Department's Master's Degree Advisor. Students who choose Plan I will also need to complete the Graduate Division's online Advancement to Candidacy form through Calcentral (https://calcentral.berkeley.edu/) no later than the end of the second week of classes in their final semester.

Once a student has advanced to candidacy, candidacy is valid for three years.

Capstone/Thesis (Plan I)

Students planning to use Plan I for their MS Degree will need to follow the Graduate Division's “Thesis Filing Guidelines." (https://grad.berkeley.edu/academic-progress/thesis/) A copy of the signature page and abstract should be submitted to the Department's Master's Degree Advisor. In addition, a copy should be uploaded to the EECS website (https://eecs.berkeley.edu/research/).

Capstone/Master's Project (Plan II)

Students planning to use Plan II for their MS Degree will need to produce an MS Plan II Title/Signature Page. A copy of the signature page and abstract should be submitted to the the Department's Master's Degree Advisor. In addition, a copy should be uploaded to the EECS website (https://eecs.berkeley.edu/research/).

There is no special formatting required for the body of the Plan II MS report, unlike the Plan I MS thesis, which must follow Graduate Division guidelines.

Unit Requirements

The minimum number of units to complete the degree is 25 semester units.

Curriculum

Four Graduate Level Classes (two in Fall and two in Spring) from courses chosen by Master’s Vice Chair

EL ENG 206A	Introduction to Robotics	4
EL ENG 206B	Robotic Manipulation and Interaction	4
EL ENG 210	Applied Electromagnetic Theory	3
EL ENG 213A	Power Electronics	4
EL ENG C213	X-rays and Extreme Ultraviolet Radiation	3
EL ENG 218A	Introduction to Optical Engineering	4
EL ENG 219A	Course Not Available	4
EL ENG 219B	Logic Synthesis	4
EL ENG C220A	Advanced Control Systems I	3
EL ENG C220B	Experiential Advanced Control Design I	3
EL ENG C220C	Experiential Advanced Control Design II	3
EL ENG 221A	Linear System Theory	4
EL ENG 222	Nonlinear Systems--Analysis, Stability and Control	3
EL ENG C222	Nonlinear Systems	3
EL ENG 223	Stochastic Systems: Estimation and Control	3
EL ENG 224A	Digital Communications	4
EL ENG 224B	Fundamentals of Wireless Communication	3
EL ENG 225D	Audio Signal Processing in Humans and Machines	3
EL ENG C225E	Principles of Magnetic Resonance Imaging	4
EL ENG 226A	Random Processes in Systems	4
EL ENG 226B	Applications of Stochastic Process Theory	2
EL ENG 227BT	Convex Optimization	4
EL ENG C227C	Convex Optimization and Approximation	3
EL ENG C227T	Introduction to Convex Optimization	4
EL ENG 228A	High Speed Communications Networks	3
EL ENG 229A	Information Theory and Coding	3
EL ENG 229B	Error Control Coding	3
EL ENG 230A	Integrated-Circuit Devices	4
EL ENG 230B	Solid State Devices	4
EL ENG 230C	Solid State Electronics	3
EL ENG 232	Lightwave Devices	4
EL ENG C235	Nanoscale Fabrication	4
EL ENG 236A	Quantum and Optical Electronics	3
EL ENG C239	Partially Ionized Plasmas	3
EL ENG 240A	Analog Integrated Circuits	4
EL ENG 240B	Advanced Analog Integrated Circuits	4
EL ENG 240C	Analysis and Design of VLSI Analog-Digital Interface Integrated Circuits	3
EL ENG W241A	Introduction to Digital Integrated Circuits	4
EL ENG 241B	Advanced Digital Integrated Circuits	3
EL ENG W241B	Advanced Digital Integrated Circuits	3
EL ENG 242A	Integrated Circuits for Communications	4
EL ENG 242B	Advanced Integrated Circuits for Communications	3
EL ENG W242A	Integrated Circuits for Communications	4
EL ENG W242B	Advanced Integrated Circuits for Communications	3
EL ENG 243	Advanced IC Processing and Layout	3
EL ENG 244	Fundamental Algorithms for Systems Modeling, Analysis, and Optimization	4
EL ENG W244	Fundamental Algorithms for System Modeling, Analysis, and Optimization	4
EL ENG 247A	Introduction to Microelectromechanical Systems (MEMS)	3
EL ENG C247B	Introduction to MEMS Design	4
EL ENG 248C	Numerical Modeling and Analysis: Nonlinear Systems and Noise	4
EL ENG C249A	Introduction to Embedded Systems	4
EL ENG C249B	Course Not Available	4
EL ENG C261	Medical Imaging Signals and Systems	4
EL ENG 290	Advanced Topics in Electrical Engineering	1-4
EL ENG C291	Control and Optimization of Distributed Parameters Systems	3
EL ENG C291E	Hybrid Systems and Intelligent Control	3
EECS C206A	Introduction to Robotics	4
EECS C206B	Robotic Manipulation and Interaction	4
EECS 208	Computational Principles for High-dimensional Data Analysis	4
EECS 219C	Formal Methods: Specification, Verification, and Synthesis	3
EECS 225A	Statistical Signal Processing	3
EECS 225B	Digital Image Processing	3
EECS 227AT	Optimization Models in Engineering	4
EECS 251A	Introduction to Digital Design and Integrated Circuits	3

EECS 251B	Advanced Digital Integrated Circuits and Systems	4
EECS 251LA	Introduction to Digital Design and Integrated Circuits Lab	2
EECS 251LB	Introduction to Digital Design and Integrated Circuits Lab	2
COMPSCI C200A	Principles and Techniques of Data Science	4
COMPSCI C249A	Introduction to Embedded Systems	4
COMPSCI 250	VLSI Systems Design	4
COMPSCI 252A	Graduate Computer Architecture	4
COMPSCI 260A	User Interface Design and Development	4
COMPSCI 260B	Human-Computer Interaction Research	3
COMPSCI 261	Security in Computer Systems	3
COMPSCI 262A	Advanced Topics in Computer Systems	4
COMPSCI 262B	Advanced Topics in Computer Systems	3
COMPSCI 263	Design of Programming Languages	3
COMPSCI 264	Implementation of Programming Languages	4
COMPSCI 265	Compiler Optimization and Code Generation	3
COMPSCI C267	Applications of Parallel Computers	3
COMPSCI 268	Computer Networks	3
COMPSCI 270	Combinatorial Algorithms and Data Structures	3
COMPSCI 271	Randomness and Computation	3
COMPSCI 273	Course Not Available	3
COMPSCI 274	Computational Geometry	3
COMPSCI 276	Cryptography	3
COMPSCI C280	Computer Vision	3
COMPSCI C281A	Statistical Learning Theory	3
COMPSCI C281B	Advanced Topics in Learning and Decision Making	3
COMPSCI 282A	Designing, Visualizing and Understanding Deep Neural Networks	4
COMPSCI 284A	Foundations of Computer Graphics	4
COMPSCI 284B	Advanced Computer Graphics Algorithms and Techniques	4
COMPSCI 285	Deep Reinforcement Learning, Decision Making, and Control	3
COMPSCI 286A	Course Not Available	4
COMPSCI 286B	Course Not Available	3
COMPSCI 287	Advanced Robotics	3
COMPSCI 287H	Algorithmic Human-Robot Interaction	4
COMPSCI 288	Natural Language Processing	4
COMPSCI 289A	Introduction to Machine Learning	4
COMPSCI 294	Special Topics	1-4
Six units of Engineering 270 (1 Units each) — ENGIN 270 AB and C in Fall and three more in Spring		
ENGIN 270A	Organizational Behavior for Engineers	1
ENGIN 270B	R&D Technology Management & Ethics	1
ENGIN 270C	Teaming & Project Management	1
ENGIN 270D	Entrepreneurship for Engineers	1
ENGIN 270E	Technology Strategy & Industry Analysis	1
ENGIN 270F	Data Analytics	1
ENGIN 270G	Marketing & Product Management	1
ENGIN 270H	Accounting & Finance for Engineers	1
ENGIN 270I	Technology Strategy for Engineering Leaders	1
ENGIN 270J	Industry Analysis for Engineering Leaders	1
ENGIN 270K	Coaching for High Performance Teams	1
ENGIN 270L	Global Leadership Expertise	1
ENGIN 270M	Professional Ethics in Technology, Law and Business	1
ENGIN 270N	Innovation Management	1
ENGIN 270P	Power and Persuasion for Engineering Leadership	1
Plus 4–5 Units of Capstone Project		
ENGIN 296MA	Master of Engineering Capstone Project	1-12
ENGIN 296MB	Master of Engineering Capstone Project	1-5

Capstone/Master's Project (Plan II)

Students will join a team of three to five students, working on a specific problem or opportunity that can be addressed by technology and gaining direct experience in applying the skills learned in leadership courses.

Select a subject to view courses

- Electrical Engineering and Computer Sciences (p. 8)
- Computer Science (p. 14)
- Electrical Engineering (p. 26)

Electrical Engineering and Computer Sciences

EECS C206A Introduction to Robotics 4 Units

Terms offered: Fall 2025, Fall 2024, Fall 2023

This course is an introduction to the field of robotics. It covers the fundamentals of kinematics, dynamics, control of robot manipulators, robotic vision, sensing, forward & inverse kinematics of serial chain manipulators, the manipulator Jacobian, force relations, dynamics, & control. We will present techniques for geometric motion planning & obstacle avoidance. Open problems in trajectory generation with dynamic constraints will also be discussed. The course also presents the use of the same analytical techniques as manipulation for the analysis of images & computer vision. Low level vision, structure from motion, & an introduction to vision & learning will be covered. The course concludes with current applications of robotics.

Rules & Requirements

Prerequisites: Familiarity with linear algebra at level of EECS 16A/ EECS 16B or MATH 54. Experience doing coding in python at the level of COMPSCI 61A. Preferred: experience developing software at level of COMPSCI 61B and experience using Linux. EECS 120 is not required, but some knowledge of linear systems may be helpful for the control of robots

Hours & Format

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

Additional Details

Subject/Course Level: Electrical Engin and Computer Sci/Graduate

Grading: Letter grade.

Instructors: Sastry, Sreenath

Formerly known as: Electrical Engin and Computer Sci 206A

Also listed as: MEC ENG C206A

EECS C206B Robotic Manipulation and Interaction 4 Units

Terms offered: Spring 2025, Spring 2024, Spring 2023
This course is a sequel to EECS C106A/206A, which covers kinematics, dynamics and control of a single robot. This course will cover dynamics and control of groups of robotic
manipulators coordinating with each other and interacting with the environment. Concepts will include
an introduction to grasping and the constrained manipulation, contacts and force control for interaction
with the environment. We will also cover active perception guided manipulation, as well as the
manipulation of non-rigid objects. Throughout, we will emphasize design and human-robot
interactions, and applications to applications in manufacturing, service robotics, tele-surgery, and
locomotion.
Rules & Requirements

Prerequisites: Students are expected to have taken EECS C106A / BioE C106A / ME C106A / ME C206A/ EECS C206A or an equivalent course. A strong programming background, knowledge of Python and Matlab, and some coursework in feedback controls (such as EE C128 / ME C134) are also useful. Students who have not taken EECS C106A / BioE C106A / ME C106A / ME C206A/ EECS C206A should have a strong programming background, knowledge of Python and Matlab, and exposure to linear algebra, and Lagrangian dynamics

Hours & Format

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

Additional Details

Subject/Course Level: Electrical Engin and Computer Sci/Graduate

Grading: Letter grade.

Instructors: Bajcsy, Sastry

Formerly known as: Electrical Engin and Computer Sci 206B

Also listed as: MEC ENG C206B

EECS 208 Computational Principles for High-dimensional Data Analysis 4 Units

Terms offered: Fall 2023, Fall 2022, Fall 2021
Introduction to fundamental geometric and statistical concepts and principles of low-dimensional models for high-dimensional signal and data analysis, spanning basic theory, efficient algorithms, and diverse real-world applications. Systematic study of both sampling complexity and computational complexity for sparse, low-rank, and low-dimensional models – including important cases such as matrix completion, robust principal component analysis, dictionary learning, and deep networks.
Rules & Requirements

Prerequisites: The following courses are recommended undergraduate linear algebra (Math 110), statistics (Stat 134), and probability (EE126). Back-ground in signal processing (ELENG 123), optimization (ELENG C227T), machine learning (CS189/289), and computer vision (COMPSCI C280) may allow you to appreciate better certain aspects of the course material, but not necessary all at once. The course is open to senior undergraduates, with consent from the instructor

Hours & Format

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

Additional Details

Subject/Course Level: Electrical Engin and Computer Sci/Graduate

Grading: Letter grade.

Instructor: Ma

EECS 219A Numerical Simulation and Modeling 4 Units

Terms offered: Spring 2025, Spring 2024
Numerical simulation and modeling are enabling technologies that pervade science and engineering. This course provides a detailed introduction to the fundamental principles of these technologies and their translation to engineering practice. The course emphasizes hands-on programming in MATLAB and application to several domains, including circuits, nanotechnology, and biology.
Rules & Requirements

Prerequisites: Consent of instructor; a course in linear algebra and on circuits is very useful

Credit Restrictions: Students will receive no credit for EL ENG 219A after completing EL ENG 219.

Hours & Format

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

Additional Details

Subject/Course Level: Electrical Engin and Computer Sci/Graduate

Grading: Letter grade.

Instructor: Roychowdhury

Formerly known as: Electrical Engineering 219A

EECS 219C Formal Methods: Specification, Verification, and Synthesis 3 Units

Terms offered: Spring 2025, Spring 2024, Spring 2023
Introduction to the theory and practice of formal methods for the design and analysis of systems, with a focus on algorithmic techniques. Covers selected topics in computational logic and automata theory including modeling and specification formalisms, temporal logics, satisfiability solving, model checking, synthesis, learning, and theorem proving. Applications to software and hardware design, cyber-physical systems, robotics, computer security, and other areas will be explored as time permits.

Rules & Requirements

Prerequisites: Graduate standing or consent of instructor; COMPSCI 170 is recommended

Hours & Format

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

Additional Details

Subject/Course Level: Electrical Engin and Computer Sci/Graduate

Grading: Letter grade.

Instructor: Seshia

Formerly known as: Electrical Engineering 219C

EECS 225A Statistical Signal Processing 3 Units

Terms offered: Fall 2025, Spring 2025, Spring 2023
This course connects classical statistical signal processing (Hilbert space filtering theory by Wiener and Kolmogorov, state space model, signal representation, detection and estimation, adaptive filtering) with modern statistical and machine learning theory and applications. It focuses on concrete algorithms and combines principled theoretical thinking with real applications.

Rules & Requirements

Prerequisites: EL ENG 120 and EECS 126

Hours & Format

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

Additional Details

Subject/Course Level: Electrical Engin and Computer Sci/Graduate

Grading: Letter grade.

Instructors: Jiao, Waller

Formerly known as: Electrical Engineering 225A

EECS 225B Digital Image Processing 3 Units

Terms offered: Fall 2023, Fall 2022, Fall 2020
This course deals with computational methods as applied to digital imagery. It focuses on image sensing and acquisition, image sampling and quantization; spatial transformation, linear and nonlinear filtering; introduction to convolutional neural networks, and GANs; applications of deep learning methods to image processing problems; image enhancement, histogram equalization, image restoration, Weiner filtering, tomography, image reconstruction from projections and partial Fourier information, Radon transform, multiresolution analysis, continuous and discrete wavelet transform and computation, subband coding, image and video compression, sparse signal approximation, dictionary techniques, image and video compression standards, and more.

Rules & Requirements

Prerequisites: Basic knowledge of signals and systems, convolution, and Fourier Transform

Hours & Format

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

Additional Details

Subject/Course Level: Electrical Engin and Computer Sci/Graduate

Grading: Letter grade.

Instructor: Zakhor

Formerly known as: Electrical Engineering 225B

EECS 227AT Optimization Models in Engineering 4 Units

Terms offered: Fall 2025, Spring 2025, Fall 2024
This course offers an introduction to optimization models and their applications, ranging from machine learning and statistics to decision-making and control, with emphasis on numerically tractable problems, such as linear or constrained least-squares optimization.

Rules & Requirements

Prerequisites: MATH 54 or consent of instructor

Credit Restrictions: Students will receive no credit for EECS 227AT after taking EECS 127 or Electrical Engineering 127/227AT.

Hours & Format

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

Additional Details

Subject/Course Level: Electrical Engin and Computer Sci/Graduate

Grading: Letter grade.

Instructor: El Ghaoui

Formerly known as: Electrical Engineering 227AT

EECS C249B Cyber Physical System Design Prinicples and Applications 4 Units

Terms offered: Spring 2020, Spring 2019, Spring 2016
Principles of embedded system design. Focus on design methodologies and foundations. Platform-based design and communication-based design and their relationship with design time, re-use, and performance. Models of computation and their use in design capture, manipulation, verification, and synthesis. Mapping into architecture and systems platforms. Performance estimation. Scheduling and real-time requirements. Synchronous languages and time-triggered protocols to simplify the design process.

Rules & Requirements

Prerequisites: Suggested but not required: CS170, EECS149/249A

Credit Restrictions: Students will receive no credit for EECS C249B after completing EL ENG 249, or EECS 249B. A deficient grade in EECS C249B may be removed by taking EECS 249B.

Hours & Format

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

Additional Details

Subject/Course Level: Electrical Engin and Computer Sci/Graduate

Grading: Letter grade.

Instructor: Sangiovanni-Vincentelli

Formerly known as: Electrical Engineering C249B/Civil and Environmental Engineering C289

Also listed as: CIV ENG C289

EECS 251A Introduction to Digital Design and Integrated Circuits 3 Units

Terms offered: Fall 2025, Spring 2025, Fall 2024
An introduction to digital circuit and system design. The material provides a top-down view of the principles, components, and methodologies for large scale digital system design. The underlying CMOS devices and manufacturing technologies are introduced, but quickly abstracted to higher levels to focus the class on design of larger digital modules for both FPGAs (field programmable gate arrays) and ASICs (application specific integrated circuits). The class includes extensive use of industrial grade design automation and verification tools for assignments, labs, and projects.

Objectives & Outcomes

Course Objectives: The Verilog hardware description language is introduced and used. Basic digital system design concepts, Boolean operations/combinational logic, sequential elements and finite-state-machines, are described. Design of larger building blocks such as arithmetic units, interconnection networks, input/output units, as well as memory design (SRAM, Caches, FIFOs) and integration are also covered. Parallelism, pipelining and other micro-architectural optimizations are introduced. A number of physical design issues visible at the architecture level are covered as well, such as interconnects, power, and reliability.

Student Learning Outcomes: Although the syllabus is the same as EECS151, the assignments and exams for EECS251A will have harder problems that test deeper understanding expected from a graduate level course.

Rules & Requirements

Prerequisites: EECS 16A and EECS 16B; COMPSCI 61C; and recommended: EL ENG 105. Students must enroll concurrently in at least one the laboratory flavors EECS 251LA or EECS 251LB. Students wishing to take a second laboratory flavor next term can sign-up only for that laboratory section and receive a letter grade. The prerequisite for “Lab-only” enrollment that term will be EECS 251A from previous terms

Credit Restrictions: Students must enroll concurrently in at least one the laboratory flavors Electrical Engineering and Computer Science 251LA or Electrical Engineering and Computer Science 251LB. Students wishing to take a second laboratory flavor next term can sign-up only for that laboratory section and receive a letter grade. The pre-requisite for “Lab-only” enrollment that term will be Electrical Engineering and Computer Science 251A from previous terms.

Hours & Format

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

Additional Details

Subject/Course Level: Electrical Engin and Computer Sci/Graduate

Grading: Letter grade.

Instructors: Stojanovic, Wawrzynek

Formerly known as: Electrical Engineering 241A

EECS 251B Advanced Digital Integrated Circuits and Systems 4 Units

Terms offered: Spring 2025, Spring 2024, Spring 2023
This course aims to convey a knowledge of advanced concepts of digital circuit and system-on-a-chip design in state-of-the-art technologies. Emphasis is on the circuit and system design and optimization for both energy efficiency and high performance for use in a broad range of applications, from edge computing to datacenters. Special attention will be devoted to the most important challenges facing digital circuit designers in the coming decade. The course is accompanied with practical laboratory exercises that introduce students to modern tool flows.

Rules & Requirements

Prerequisites: Introduction to Digital Design and Integrated Circuits, EECS151 (taken with either EECS151LA or EECS151LB lab) or EECS251A (taken with either EECS251LA or EECS251LB lab)

Credit Restrictions: Students will receive no credit for EECS 251B after completing COMPSCI 250, or EL ENG 241B.

Hours & Format

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

Additional Details

Subject/Course Level: Electrical Engin and Computer Sci/Graduate

Grading: Letter grade.

Instructors: Nikoli#, Shao, Wawrzynek, Asanovi#, Stojanovi#, Seshia

EECS 251LA Introduction to Digital Design and Integrated Circuits Lab 2 Units

Terms offered: Fall 2025, Spring 2025, Fall 2024
This lab lays the foundation of modern digital design by first presenting the scripting and hardware description language base for specification of digital systems and interactions with tool flows. The labs are centered on a large design with the focus on rapid design space exploration. The lab exercises culminate with a project design, e.g. implementation of a 3-stage RISC-V processor with a register file and caches. The design is mapped to simulation and layout specification.

Objectives & Outcomes

Course Objectives: Software testing of digital designs is covered leading to a set of exercises that cover the design flow. Digital synthesis, floor-planning, placement and routing are covered, as well as tools to evaluate timing and power consumption. Chip-level assembly is covered, including instantiation of custom blocks: I/O pads, memories, PLLs, etc.

Student Learning Outcomes: Although the syllabus is the same as EECS151LA, the assignments and exams for EECS251LA will have harder problems in labs and in the project that test deeper understanding expected from a graduate level course.

Rules & Requirements

Prerequisites: EECS 16A, EECS 16B, and COMPSCI 61C; and EL ENG 105 is recommended

Hours & Format

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

Additional Details

Subject/Course Level: Electrical Engin and Computer Sci/Graduate

Grading: Letter grade.

Instructors: Stojanovic, Wawrzynek

EECS 251LB Introduction to Digital Design and Integrated Circuits Lab 2 Units

Terms offered: Fall 2025, Spring 2025, Fall 2024
This lab covers the design of modern digital systems with Field-Programmable Gate Array (FPGA) platforms. A series of lab exercises provide the background and practice of digital design using a modern FPGA design tool flow. Digital synthesis, partitioning, placement, routing, and simulation tools for FPGAs are covered in detail. The labs exercises culminate with a large design project, e.g., an implementation of a full 3-stage RISC-V processor system, with caches, graphics acceleration, and external peripheral components. The design is mapped and demonstrated on an FPGA hardware platform.

Objectives & Outcomes

Student Learning Outcomes: Although the syllabus is the same as EECS151LB, the assignments and exams for EECS251LB will have harder problems in labs and in the project that test deeper understanding expected from a graduate level course.

Rules & Requirements

Prerequisites: EECS 16A, EECS 16B, and COMPSCI 61C; and EL ENG 105 is recommended

Hours & Format

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

Additional Details

Subject/Course Level: Electrical Engin and Computer Sci/Graduate

Grading: Letter grade.

Instructors: Stojanovic, Wawrzynek

EECS 283A Natural Language Processing 4 Units

Terms offered: Fall 2025
This course provides a hands-on introduction to language technologies, covering methods for processing speech and text. This includes: statistical models, early neural models, and transformer-based LLMs; model architectures, training, evaluation, and social impacts; core tasks and methods like machine translation, parsing, and prompting; analysis and representation of speech and speech recognition models. Weekly assignments provide practical experience in building systems and understanding their strengths and limitations.

Rules & Requirements

Prerequisites: COMPSCI C182, COMPSCI 188, or COMPSCI 189

Credit Restrictions: Students will receive no credit for EECS 283A after completing COMPSCI 288. A deficient grade in EECS 283A may be removed by taking COMPSCI 288.

Hours & Format

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

Additional Details

Subject/Course Level: Electrical Engin and Computer Sci/Graduate

Grading: Letter grade.

Instructors: Suhr, Anumanchipalli

Computer Science

COMPSCI C200A Principles and Techniques of Data Science 4 Units

Terms offered: Spring 2025, Fall 2024, Spring 2024, Spring 2023, Spring 2022, Spring 2021, Spring 2020
Explores the data science lifecycle: question formulation, data collection and cleaning, exploratory, analysis, visualization, statistical inference, prediction, and decision-making. Focuses on quantitative critical thinking and key principles and techniques: languages for transforming, querying and analyzing data; algorithms for machine learning methods: regression, classification and clustering; principles of informative visualization; measurement error and prediction; and techniques for scalable data processing. Research term project.
Rules & Requirements

Prerequisites: COMPSCI C8 / INFO C8 / STAT C8 or ENGIN 7; and either COMPSCI 61A or COMPSCI 88. Corequisites: MATH 54 or EECS 16A

Credit Restrictions: Students will receive no credit for DATA C200\COMPSCI C200A\STAT C200C after completing DATA C100.

Hours & Format

Fall and/or spring:
8 weeks - 6-6 hours of lecture, 2-2 hours of discussion, and 0-2 hours of laboratory per week
15 weeks - 3-3 hours of lecture, 1-1 hours of discussion, and 0-1 hours of laboratory per week

Summer: 8 weeks - 6-6 hours of lecture, 2-2 hours of discussion, and 0-2 hours of laboratory per week

Additional Details

Subject/Course Level: Computer Science/Graduate

Grading: Letter grade.

Formerly known as: Statistics C200C/Computer Science C200A

Also listed as: DATA C200/STAT C200C

COMPSCI C249A Introduction to Embedded Systems 4 Units

Terms offered: Fall 2025, Fall 2024, Fall 2023
This course introduces students to the basics of models, analysis tools, and control for embedded systems operating in real time. Students learn how to combine physical processes with computation. Topics include models of computation, control, analysis and verification, interfacing with the physical world, mapping to platforms, and distributed embedded systems. The course has a strong laboratory component, with emphasis on a semester-long sequence of projects.
Rules & Requirements

Credit Restrictions: Students will receive no credit for Electrical Engineering/Computer Science C249A after completing Electrical Engineering/Computer Science C149.

Hours & Format

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

Additional Details

Subject/Course Level: Computer Science/Graduate

Grading: Letter grade.

Instructors: Lee, Seshia

Formerly known as: Electrical Engineering C249M/Computer Science C249M

Also listed as: EL ENG C249A

COMPSCI 250 VLSI Systems Design 4 Units

Terms offered: Fall 2020, Spring 2017, Spring 2016
Unified top-down and bottom-up design of integrated circuits and systems concentrating on architectural and topological issues. VLSI architectures, systolic arrays, self-timed systems. Trends in VLSI development. Physical limits. Tradeoffs in custom-design, standard cells, gate arrays. VLSI design tools.
Rules & Requirements

Prerequisites: COMPSCI 150

Hours & Format

Fall and/or spring: 15 weeks - 3 hours of lecture and 4 hours of laboratory per week

Additional Details

Subject/Course Level: Computer Science/Graduate

Grading: Letter grade.

Instructor: Wawrzynek

COMPSCI 252A Graduate Computer Architecture 4 Units

Terms offered: Spring 2025, Spring 2024, Spring 2023
Graduate survey of contemporary computer organizations covering: early systems, CPU design, instruction sets, control, processors, busses, ALU, memory, I/O interfaces, connection networks, virtual memory, pipelined computers, multiprocessors, and case studies. Term paper or project is required.

Rules & Requirements

Prerequisites: COMPSCI 61C

Hours & Format

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

Additional Details

Subject/Course Level: Computer Science/Graduate

Grading: Letter grade.

Instructors: Asanovi#, Kubiatowicz

Formerly known as: Computer Science 252

COMPSCI 260A User Interface Design and Development 4 Units

Terms offered: Fall 2025, Spring 2025, Spring 2024
The design, implementation, and evaluation of user interfaces. User-centered design and task analysis. Conceptual models and interface metaphors. Usability inspection and evaluation methods. Analysis of user study data. Input methods (keyboard, pointing, touch, tangible) and input models. Visual design principles. Interface prototyping and implementation methodologies and tools. Students will develop a user interface for a specific task and target user group in teams.

Rules & Requirements

Prerequisites: COMPSCI 61B, COMPSCI 61BL, or consent of instructor

Credit Restrictions: Students will receive no credit for Computer Science 260A after taking Computer Science 160.

Hours & Format

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

Additional Details

Subject/Course Level: Computer Science/Graduate

Grading: Letter grade.

Instructors: Agrawala, Canny, Hartmann

COMPSCI 260B Human-Computer Interaction Research 3 Units

Terms offered: Fall 2024, Fall 2017
This course is a broad introduction to conducting research in Human-Computer Interaction. Students will become familiar with seminal and recent literature; learn to review and critique research papers; re-implement and evaluate important existing systems; and gain experience in conducting research. Topics include input devices, computer-supported cooperative work, crowdsourcing, design tools, evaluation methods, search and mobile interfaces, usable security, help and tutorial systems.

Rules & Requirements

Prerequisites: COMPSCI 160 recommended, or consent of instructor

Hours & Format

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

Additional Details

Subject/Course Level: Computer Science/Graduate

Grading: Letter grade.

Instructor: Hartmann

COMPSCI 261 Security in Computer Systems 3 Units

Terms offered: Fall 2023, Spring 2021, Fall 2018
Graduate survey of modern topics in computer security, including protection, access control, distributed access security, firewalls, secure coding practices, safe languages, mobile code, and case studies from real-world systems. May also cover cryptographic protocols, privacy and anonymity, and/or other topics as time permits.

Rules & Requirements

Prerequisites: COMPSCI 162

Hours & Format

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

Additional Details

Subject/Course Level: Computer Science/Graduate

Grading: Letter grade.

Instructors: D. Song, Wagner

COMPSCI 261N Internet and Network Security 4 Units

Terms offered: Spring 2020, Fall 2016, Spring 2015
Develops a thorough grounding in Internet and network security suitable for those interested in conducting research in the area or those more broadly interested in security or networking. Potential topics include denial-of-service; capabilities; network intrusion detection/prevention; worms; forensics; scanning; traffic analysis; legal issues; web attacks; anonymity; wireless and networked devices; honeypots; botnets; scams; underground economy; attacker infrastructure; research pitfalls.
Rules & Requirements

Prerequisites: EL ENG 122 or equivalent; and COMPSCI 161 or familiarity with basic security concepts

Hours & Format

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

Additional Details

Subject/Course Level: Computer Science/Graduate

Grading: Letter grade.

Instructor: Paxson

COMPSCI 262A Advanced Topics in Computer Systems 4 Units

Terms offered: Fall 2025, Spring 2025, Fall 2023
Graduate survey of systems for managing computation and information, covering a breadth of topics: early systems; volatile memory management, including virtual memory and buffer management; persistent memory systems, including both file systems and transactional storage managers; storage metadata, physical vs. logical naming, schemas, process scheduling, threading and concurrency control; system support for networking, including remote procedure calls, transactional RPC, TCP, and active messages; security infrastructure; extensible systems and APIs; performance analysis and engineering of large software systems. Homework assignments, exam, and term paper or project required.
Rules & Requirements

Prerequisites: COMPSCI 162 and entrance exam

Hours & Format

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

Additional Details

Subject/Course Level: Computer Science/Graduate

Grading: Letter grade.

Instructors: Brewer, Hellerstein

Formerly known as: 262

COMPSCI 262B Advanced Topics in Computer Systems 3 Units

Terms offered: Spring 2020, Spring 2009, Fall 2008
Continued graduate survey of large-scale systems for managing information and computation. Topics include basic performance measurement; extensibility, with attention to protection, security, and management of abstract data types; index structures, including support for concurrency and recovery; parallelism, including parallel architectures, query processing and scheduling; distributed data management, including distributed and mobile file systems and databases; distributed caching; large-scale data analysis and search. Homework assignments, exam, and term paper or project required.
Rules & Requirements

Prerequisites: COMPSCI 262A

Hours & Format

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

Additional Details

Subject/Course Level: Computer Science/Graduate

Grading: Letter grade.

Instructors: Brewer, Culler, Hellerstein, Joseph

COMPSCI 263 Design of Programming Languages 3 Units

Terms offered: Fall 2021, Fall 2019, Spring 2019
Selected topics from: analysis, comparison, and design of programming languages, formal description of syntax and semantics, advanced programming techniques, structured programming, debugging, verification of programs and compilers, and proofs of correctness.
Rules & Requirements

Prerequisites: COMPSCI 164

Hours & Format

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

Additional Details

Subject/Course Level: Computer Science/Graduate

Grading: Letter grade.

Instructor: Necula

COMPSCI 264 Implementation of Programming Languages 4 Units

Terms offered: Fall 2025, Spring 2025, Fall 2023
Compiler construction. Lexical analysis, syntax analysis. Semantic analysis code generation and optimization. Storage management. Run-time organization.

Rules & Requirements

Prerequisites: COMPSCI 164; COMPSCI 263 recommended

Hours & Format

Fall and/or spring: 15 weeks - 3 hours of lecture, 1 hour of discussion, and 6 hours of laboratory per week

Additional Details

Subject/Course Level: Computer Science/Graduate

Grading: Letter grade.

Instructor: Bodik

COMPSCI 265 Compiler Optimization and Code Generation 3 Units

Terms offered: Fall 2024, Fall 2009, Spring 2003
Table-driven and retargetable code generators. Register management. Flow analysis and global optimization methods. Code optimization for advanced languages and architectures. Local code improvement. Optimization by program transformation. Selected additional topics. A term paper or project is required.

Rules & Requirements

Prerequisites: COMPSCI 164

Hours & Format

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

Additional Details

Subject/Course Level: Computer Science/Graduate

Grading: Letter grade.

Instructor: Sen

COMPSCI C267 Applications of Parallel Computers 3 - 4 Units

Terms offered: Spring 2025, Spring 2024, Spring 2023, Spring 2022, Spring 2021
Models for parallel programming. Overview of parallelism in scientific applications and study of parallel algorithms for linear algebra, particles, meshes, sorting, FFT, graphs, machine learning, etc. Survey of parallel machines and machine structures. Programming shared- and distributed-memory parallel computers, GPUs, and cloud platforms. Parallel programming languages, compilers, libraries and toolboxes. Data partitioning techniques. Techniques for synchronization and load balancing. Detailed study and algorithm/program development of medium sized applications.

Rules & Requirements

Prerequisites: No formal pre-requisites. Prior programming experience with a low-level language such as C, C++, or Fortran is recommended but not required. CS C267 is intended to be useful for students from many departments and with different backgrounds, although we will assume reasonable programming skills in a conventional (non-parallel) language, as well as enough mathematical skills to understand the problems and algorithmic solutions presented

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

Hours & Format

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

Additional Details

Subject/Course Level: Computer Science/Graduate

Grading: Letter grade.

Instructors: Demmel, Yelick

Also listed as: ENGIN C233

COMPSCI 268 Computer Networks 3 Units

Terms offered: Spring 2023, Spring 2021, Spring 2019
Distributed systems, their notivations, applications, and organization. The network component. Network architectures. Local and long-haul networks, technologies, and topologies. Data link, network, and transport protocols. Point-to-point and broadcast networks. Routing and congestion control. Higher-level protocols. Naming. Internetworking. Examples and case studies.

Rules & Requirements

Prerequisites: COMPSCI 162

Hours & Format

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

Additional Details

Subject/Course Level: Computer Science/Graduate

Grading: Letter grade.

Instructors: Joseph, Katz, Stoica

Formerly known as: 292V

COMPSCI 270 Combinatorial Algorithms and Data Structures 3 Units

Terms offered: Fall 2024, Spring 2023, Spring 2021
Design and analysis of efficient algorithms for combinatorial problems. Network flow theory, matching theory, matroid theory; augmenting-path algorithms; branch-and-bound algorithms; data structure techniques for efficient implementation of combinatorial algorithms; analysis of data structures; applications of data structure techniques to sorting, searching, and geometric problems.

Rules & Requirements

Prerequisites: COMPSCI 170

Hours & Format

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

Additional Details

Subject/Course Level: Computer Science/Graduate

Grading: Letter grade.

Instructors: Papadimitriou, Rao, Sinclair, Vazirani

COMPSCI 271 Randomness and Computation 3 Units

Terms offered: Fall 2024, Fall 2022, Spring 2020
Computational applications of randomness and computational theories of randomness. Approximate counting and uniform generation of combinatorial objects, rapid convergence of random walks on expander graphs, explicit construction of expander graphs, randomized reductions, Kolmogorov complexity, pseudo-random number generation, semi-random sources.

Rules & Requirements

Prerequisites: COMPSCI 170 and at least one course from the following: COMPSCI 270 - COMPSCI 279

Hours & Format

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

Additional Details

Subject/Course Level: Computer Science/Graduate

Grading: Letter grade.

Instructor: Sinclair

COMPSCI 272 Foundations of Decisions, Learning, and Games 4 Units

Terms offered: Fall 2025
This course introduces students to the mathematical foundation of learning in the presence of strategic and societal agency. This is a theory-oriented course that will draw from the statistical and computational foundations of machine learning, computer science, and economics. As a research-oriented course, a range of advanced topics will be explored to paint a comprehensive
picture of classical and modern approaches to learning for the purpose of decision making.These topics include foundations of learning, foundations of algorithmic game theory, cooperative and non-cooperative games, equilibria and dynamics, learning in games, information asymmetries, mechanism design, and learning with incentives.

Rules & Requirements

Prerequisites: Graduate-level mathematical maturity, including proof-based graduate-level courses in at least two, but recommended three, of the following categories: Statistics and Probability, e.g., STAT205A, STAT210B Economics, e.g., ECON207A Algorithms, e.g., CS270 Optimization, e.g., EE 227B Control theory, e.g., EE 221A

Credit Restrictions: Students will receive no credit for COMPSCI 272 after completing COMPSCI 272. A deficient grade in COMPSCI 272 may be removed by taking COMPSCI 272.

Hours & Format

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

Additional Details

Subject/Course Level: Computer Science/Graduate

Grading: Letter grade.

Instructors: Jordan, Haghtalab

COMPSCI 274 Computational Geometry 3 Units

Terms offered: Spring 2019, Spring 2017, Spring 2015
. Constructive problems in computational geometry: convex hulls, triangulations, Voronoi diagrams, arrangements of hyperplanes; relationships among these problems. Search problems: advanced data structures; subdivision search; various kinds of range searches. Models of computation; lower bounds.

Rules & Requirements

Prerequisites: COMPSCI 170

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

Hours & Format

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

Additional Details

Subject/Course Level: Computer Science/Graduate

Grading: Letter grade.

Instructor: Shewchuk

COMPSCI 276 Cryptography 3 Units

Terms offered: Fall 2024, Fall 2020, Fall 2018
Graduate survey of modern topics on theory, foundations, and applications of modern cryptography. One-way functions; pseudorandomness; encryption; authentication; public-key cryptosystems; notions of security. May also cover zero-knowledge proofs, multi-party cryptographic protocols, practical applications, and/or other topics, as time permits.

Rules & Requirements

Prerequisites: COMPSCI 170

Hours & Format

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

Additional Details

Subject/Course Level: Computer Science/Graduate

Grading: Letter grade.

Instructors: Trevisan, Wagner

COMPSCI 278 Machine-Based Complexity Theory 3 Units

Terms offered: Fall 2025, Spring 2024, Spring 2021
Properties of abstract complexity measures; Determinism vs. nondeterminism; time vs. space; complexity hierarchies; aspects of the P-NP question; relative power of various abstract machines.

Rules & Requirements

Prerequisites: 170

Hours & Format

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

Additional Details

Subject/Course Level: Computer Science/Graduate

Grading: Letter grade.

Instructor: Trevisan

COMPSCI 280A Intro to Computer Vision and Computational Photography 4 Units

Terms offered: Fall 2025, Fall 2024, Fall 2023
This course introduces students to computing with visual data (images and video). We will cover acquisition, representation, and manipulation of visual information from digital photographs (image processing), image analysis and visual understanding (computer vision), and image synthesis (computational photography). Key algorithms will be presented, ranging from classical to contemporary, with an emphasis on using these techniques to build practical systems. The hands-on emphasis will be reflected in the programming assignments, where students will acquire their own images and develop, largely from scratch, image analysis and synthesis tools for real-world applications.

Objectives & Outcomes

Course Objectives: Students will learn classic algorithms in image manipulation with Gaussian and Laplacian Pyramids, understand the hierarchy of image transformations including homographies, and how to warp an image with these transformations., Students will learn how to apply Convolutional Neural Networks for
computer vision problems and how they can be used for image manipulation.
Students will learn the fundamentals of 3D vision:
stereo, multi-view geometry, camera calibration, structure-frommotion, multi-view stereo, and the plenoptic function
mechanics of a pin-hole camera, representation of images as pixels, physics of light and the process of image formation, to manipulating the visual information using signal processing techniques in the spatial and frequency domains.

Student Learning Outcomes: After this class, students will be comfortable implementing, from scratch, these algorithms in modern programming languages and deep learning libraries.

Rules & Requirements

Prerequisites: COMPSCI 61B; MATH 53; and MATH 54, MATH 56, MATH 110, or EECS 16A. COMPSCI C182 or COMPSCI 189 should be taken as a co-requisite

Hours & Format

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

Additional Details

Subject/Course Level: Computer Science/Graduate

Grading: Letter grade.

Instructors: Efros, Kanazawa

COMPSCI C280 Computer Vision 3 Units

Terms offered: Spring 2025, Spring 2024, Spring 2023
Paradigms for computational vision. Relation to human visual perception. Mathematical techniques for representing and reasoning, with curves, surfaces and volumes. Illumination and reflectance models. Color perception. Image segmentation and aggregation. Methods for bottom-up three dimensional shape recovery: Line drawing analysis, stereo, shading, motion, texture. Use of object models for prediction and recognition.

Rules & Requirements

Prerequisites: MATH 51; MATH 52; MATH 53; and MATH 54. (Knowledge of linear algebra and calculus)

Hours & Format

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

Additional Details

Subject/Course Level: Computer Science/Graduate

Grading: Letter grade.

Instructor: Malik

Also listed as: VIS SCI C280

COMPSCI C281A Statistical Learning Theory 3 Units

Terms offered: Fall 2025, Fall 2023, Fall 2021
Classification regression, clustering, dimensionality, reduction, and density estimation. Mixture models, hierarchical models, factorial models, hidden Markov, and state space models, Markov properties, and recursive algorithms for general probabilistic inference nonparametric methods including decision trees, kernal methods, neural networks, and wavelets. Ensemble methods.

Hours & Format

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

Additional Details

Subject/Course Level: Computer Science/Graduate

Grading: Letter grade.

Instructors: Bartlett, Jordan, Wainwright

Also listed as: STAT C241A

COMPSCI C281B Advanced Topics in Learning and Decision Making 3 Units

Terms offered: Spring 2025, Spring 2024, Spring 2023
Recent topics include: Graphical models and approximate inference algorithms. Markov chain Monte Carlo, mean field and probability propagation methods. Model selection and stochastic realization. Bayesian information theoretic and structural risk minimization approaches. Markov decision processes and partially observable Markov decision processes. Reinforcement learning.

Hours & Format

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

Additional Details

Subject/Course Level: Computer Science/Graduate

Grading: Letter grade.

Instructors: Bartlett, Jordan, Wainwright

Also listed as: STAT C241B

COMPSCI 282A Designing, Visualizing and Understanding Deep Neural Networks 4 Units

Terms offered: Fall 2025, Spring 2025, Fall 2023
Deep Networks have revolutionized computer vision, language technology, robotics and control. They have growing impact in many other areas of science and engineering. They do not however, follow a closed or compact set of theoretical principles. In Yann Lecun's words they require "an interplay between intuitive insights, theoretical modeling, practical implementations, empirical studies, and scientific analyses." This course attempts to cover that ground.

Objectives & Outcomes

Student Learning Outcomes: Students will come to understand visualizing deep networks. Exploring the training and use of deep networks with visualization tools.
Students will learn design principles and best practices: design motifs that work well in particular domains, structure optimization and parameter optimization.

Understanding deep networks. Methods with formal guarantees: generative and adversarial models, tensor factorization.

Rules & Requirements

Prerequisites: MATH 53 and MATH 54 or equivalent; COMPSCI 70 or STAT 134; COMPSCI 61B or equivalent; COMPSCI 189 or COMPSCI 289A (recommended)

Hours & Format

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

Additional Details

Subject/Course Level: Computer Science/Graduate

Grading: Letter grade.

Instructor: Canny

COMPSCI 284A Foundations of Computer Graphics 4 Units

Terms offered: Spring 2025, Spring 2024, Spring 2023
Techniques of modeling objects for the purpose of computer rendering: boundary representations, constructive solids geometry, hierarchical scene descriptions. Mathematical techniques for curve and surface representation. Basic elements of a computer graphics rendering pipeline; architecture of modern graphics display devices. Geometrical transformations such as rotation, scaling, translation, and their matrix representations. Homogeneous coordinates, projective and perspective transformations.

Rules & Requirements

Prerequisites: COMPSCI 61B or COMPSCI 61BL; programming skills in C, C++, or Java; linear algebra and calculus; or consent of instructor

Credit Restrictions: Students will receive no credit for Computer Science 284A after taking 184.

Hours & Format

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

Additional Details

Subject/Course Level: Computer Science/Graduate

Grading: Letter grade.

Instructors: Agrawala, Barsky, O'Brien, Ramamoorthi, Sequin

COMPSCI 284B Advanced Computer Graphics Algorithms and Techniques 4 Units

Terms offered: Spring 2024, Spring 2022, Spring 2019
This course provides a graduate-level introduction to advanced computer graphics algorithms and techniques. Students should already be familiar with basic concepts such as transformations, scan-conversion, scene graphs, shading, and light transport. Topics covered in this course include global illumination, mesh processing, subdivision surfaces, basic differential geometry, physically based animation, inverse kinematics, imaging and computational photography, and precomputed light transport.

Rules & Requirements

Prerequisites: COMPSCI 184

Hours & Format

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

Additional Details

Subject/Course Level: Computer Science/Graduate

Grading: Letter grade.

Instructors: O'Brien, Ramamoorthi

Formerly known as: Computer Science 283

COMPSCI 285 Deep Reinforcement Learning, Decision Making, and Control 3 Units

Terms offered: Fall 2023, Fall 2022, Fall 2021
Intersection of control, reinforcement learning, and deep learning. Deep learning methods, which train large parametric function approximators, achieve excellent results on problems that require reasoning about unstructured real-world situations (e.g., computer vision, speech recognition, NLP). Advanced treatment of the reinforcement learning formalism, the most critical model-free reinforcement learning algorithms (policy gradients, value function and Q-function learning, and actor-critic), a discussion of model-based reinforcement learning algorithms, an overview of imitation learning, and a range of advanced topics (e.g., exploration, model-based learning with video prediction, transfer learning, multi-task learning, and meta-learning).

Objectives & Outcomes

Student Learning Outcomes: Provide an opportunity to embark on a research-level final project with support from course staff.
Provide hands-on experience with several commonly used RL algorithms;
Provide students with an overview of advanced deep reinforcement learning topics, including current research trends;
Provide students with foundational knowledge to understand deep reinforcement learning algorithms;

Rules & Requirements

Prerequisites: CS189/289A or equivalent is a prerequisite for the course. This course will assume some familiarity with reinforcement learning, numerical optimization and machine learning, as well as a basic working knowledge of how to train deep neural networks (which is taught in CS182 and briefly covered in CS189)

Hours & Format

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

Additional Details

Subject/Course Level: Computer Science/Graduate

Grading: Letter grade.

Instructors: Levine, Abbeel

COMPSCI 286 Implementation of Data Base Systems 3 Units

Terms offered: Fall 2009, Spring 2009, Spring 2008
Implementation of data base systems on modern hardware systems. Considerations concerning operating system design, including buffering, page size, prefetching, etc. Query processing algorithms, design of crash recovery and concurrency control systems. Implementation of distributed data bases and data base machines.

Rules & Requirements

Prerequisites: COMPSCI 162 and COMPSCI 186; or COMPSCI 286A

Hours & Format

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

Additional Details

Subject/Course Level: Computer Science/Graduate

Grading: Letter grade.

Instructors: Franklin, Hellerstein

Formerly known as: Computer Science 286B

COMPSCI 287 Advanced Robotics 3 Units

Terms offered: Fall 2019, Fall 2015, Spring 2015
Advanced topics related to current research in algorithms and artificial intelligence for robotics. Planning, control, and estimation for realistic robot systems, taking into account: dynamic constraints, control and sensing uncertainty, and non-holonomic motion constraints.

Rules & Requirements

Prerequisites: Instructor consent for undergraduate and masters students

Hours & Format

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

Additional Details

Subject/Course Level: Computer Science/Graduate

Grading: Letter grade.

Instructor: Abbeel

COMPSCI 287H Algorithmic Human-Robot Interaction 4 Units

Terms offered: Spring 2023, Spring 2021, Spring 2020
As robot autonomy advances, it becomes more and more important to develop algorithms that are not solely functional, but also mindful of the end-user. How should the robot move differently when it's moving in the presence of a human? How should it learn from user feedback? How should it assist the user in accomplishing day to day tasks? These are the questions we will investigate in this course.
We will contrast existing algorithms in robotics with studies in human-robot interaction, discussing how to tackle interaction challenges in an algorithmic way, with the goal of enabling generalization across robots and tasks. We will also sharpen research skills: giving good talks, experimental design, statistical analysis, literature surveys.

Objectives & Outcomes

Student Learning Outcomes: Students will have gained both knowledge/abilities related to human-robot interaction, as well as to research and presentation skills including being able to
apply Bayesian inference and learning techniques to enhance coordination in collaborative tasks.
Students will have gained both knowledge/abilities related to human-robot interaction, as well as to research and presentation skills including being able to
apply optimization techniques to generate motion for HRI.
Students will have gained both knowledge/abilities related to human-robot interaction, as well as to research and presentation skills including being able to
contrast and relate model-based and model-free learning from demonstration.
Students will have gained both knowledge/abilities related to human-robot interaction, as well as to research and presentation skills including being able to
develop a basic understanding of verbal and non-verbal communication.
Students will have gained both knowledge/abilities related to human-robot interaction, as well as to research and presentation skills including being able to
ground algorithmic HRI in the relvant psychology background.
Students will have gained both knowledge/abilities related to human-robot interaction, as well as to research and presentation skills including being able to
tease out the intricacies of developing algorithms that support HRI.
Students will have gained both knowledge/abilities related to human-robot interaction, as well as to research and presentation skills including being able to analyze and diagram the literature related to a particular topic.
Students will have gained both knowledge/abilities related to human-robot interaction, as well as to research and presentation skills including being able to communicate scientific content to a peer audience.
Students will have gained both knowledge/abilities related to human-robot interaction, as well as to research and presentation skills including being able to critique a scientific paper's experimental design and analysis.

Hours & Format

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

Additional Details

Subject/Course Level: Computer Science/Graduate

Grading: Letter grade.

Instructor: Dragan

COMPSCI 288 Natural Language Processing 4 Units

Terms offered: Fall 2024, Fall 2023, Spring 2023
Methods and models for the analysis of natural (human) language data. Topics include: language modeling, speech recognition, linguistic analysis (syntactic parsing, semantic analysis, reference resolution, discourse modeling), machine translation, information extraction, question answering, and computational linguistics techniques.
Rules & Requirements

Prerequisites: COMPSCI 188; and COMPSCI 170 is recommended

Hours & Format

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

Additional Details

Subject/Course Level: Computer Science/Graduate

Grading: Letter grade.

Instructor: Klein

COMPSCI 289A Introduction to Machine Learning 4 Units

Terms offered: Fall 2025, Spring 2025, Fall 2024
This course provides an introduction to theoretical foundations, algorithms, and methodologies for machine learning, emphasizing the role of probability and optimization and exploring a variety of real-world applications. Students are expected to have a solid foundation in calculus and linear algebra as well as exposure to the basic tools of logic and probability, and should be familiar with at least one modern, high-level programming language.
Rules & Requirements

Prerequisites: MATH 53, MATH 54, COMPSCI 70, and COMPSCI 188; or consent of instructor

Credit Restrictions: Students will receive no credit for Comp Sci 289A after taking Comp Sci 189.

Hours & Format

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

Additional Details

Subject/Course Level: Computer Science/Graduate

Grading: Letter grade.

Instructors: Listgarten, Malik, Recht, Sahai, Shewchuk

COMPSCI 294 Special Topics 1 - 4 Units

Terms offered: Fall 2025, Spring 2025, Fall 2024
Topics will vary from semester to semester. See Computer Science Division announcements.
Rules & Requirements

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

Hours & Format

Fall and/or spring:
4 weeks - 3-15 hours of lecture per week
6 weeks - 3-9 hours of lecture per week
8 weeks - 2-6 hours of lecture per week
10 weeks - 2-5 hours of lecture per week
15 weeks - 1-3 hours of lecture per week

Additional Details

Subject/Course Level: Computer Science/Graduate

Grading: Letter grade.

COMPSCI 297 Field Studies in Computer Science 0 - 12 Units

Terms offered: Fall 2022, Spring 2016, Fall 2015
Supervised experience in off-campus companies relevant to specific aspects and applications of electrical engineering and/or computer science. Written report required at the end of the semester.
Rules & Requirements

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

Hours & Format

Fall and/or spring: 15 weeks - 1-12 hours of independent study per week

Summer:
6 weeks - 1-30 hours of independent study per week
8 weeks - 1.5-22.5 hours of independent study per week
10 weeks - 1-18 hours of independent study per week

Additional Details

Subject/Course Level: Computer Science/Graduate

Grading: Offered for satisfactory/unsatisfactory grade only.

COMPSCI 298 Group Studies Seminars, or Group Research 1 - 4 Units

Terms offered: Fall 2025, Spring 2025, Fall 2024
Advanced study in various subjects through seminars on topics to be selected each year, informal group studies of special problems, group participation in comprehensive design problems, or group research on complete problems for analysis and experimentation.
Rules & Requirements

Repeat rules: Course may be repeated for credit without restriction. Students may enroll in multiple sections of this course within the same semester.

Hours & Format

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

Additional Details

Subject/Course Level: Computer Science/Graduate

Grading: The grading option will be decided by the instructor when the class is offered.

COMPSCI 299 Individual Research 1 - 12 Units

Terms offered: Fall 2023, Fall 2022, Summer 2017 Second 6 Week Session
Investigations of problems in computer science.
Rules & Requirements

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

Hours & Format

Fall and/or spring: 15 weeks - 0-1 hours of independent study per week

Summer:
6 weeks - 8-30 hours of independent study per week
8 weeks - 6-22.5 hours of independent study per week
10 weeks - 1.5-18 hours of independent study per week

Additional Details

Subject/Course Level: Computer Science/Graduate

Grading: Offered for satisfactory/unsatisfactory grade only.

COMPSCI 302 Designing Computer Science Education 3 Units

Terms offered: Spring 2025, Spring 2023, Spring 2022
Discussion and review of research and practice relating to the teaching of computer science: knowledge organization and misconceptions, curriculum and topic organization, evaluation, collaborative learning, technology use, and administrative issues. As part of a semester-long project to design a computer science course, participants invent and refine a variety of homework and exam activities, and evaluate alternatives for textbooks, grading and other administrative policies, and innovative uses of technology.
Rules & Requirements

Prerequisites: COMPSCI 301 and two semesters of GSI experience

Hours & Format

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

Additional Details

Subject/Course Level: Computer Science/Professional course for teachers or prospective teachers

Grading: Letter grade.

Instructor: Garcia

COMPSCI 365 Introduction to Instructional Methods in Computer Science for Academic Interns 2 - 4 Units

Terms offered: Fall 2025, Spring 2025, Fall 2024
This is a course for aspiring Academic Interns (AIs). It provides pedagogical training and guidance to students by introducing them to the Big Ideas of Teaching and Learning, and how to put them into practice. The course covers what makes a safe learning environment, how students learn, how to guide students toward mastery, and psychosocial factors that can negatively affect even the best students and best teachers. Class covers both theoretical and practical pedagogical aspects of teaching STEM subjects—specifically Computer Science. An integral feature of the course lies in the weekly AI experience that students perform to practice their teaching skills.
Rules & Requirements

Prerequisites: Completion of any DS or CS lower-division course and concurrent participation in the Academic Intern experience in EECS at UC Berkeley

Hours & Format

Fall and/or spring: 15 weeks - 2-2 hours of lecture and 3-9 hours of fieldwork per week

Summer: 8 weeks - 4-4 hours of lecture and 6-18 hours of fieldwork per week

Additional Details

Subject/Course Level: Computer Science/Professional course for teachers or prospective teachers

Grading: Offered for satisfactory/unsatisfactory grade only.

Instructors: Hunn, Garcia

COMPSCI 370 Adaptive Instruction Methods in Computer Science 3 Units

Terms offered: Fall 2025, Spring 2025, Fall 2024
This is a course for aspiring teachers or those who want to instruct with expertise from evidence-based research and proven equity-oriented practices. It provides pedagogical training by introducing the big ideas of teaching and learning, and illustrating how to put them into practice. The course is divided into three sections—instructing the individual; a group; and psycho-social factors that affect learning at any level. These sections are designed to enhance any intern's, tutor's, or TA's teaching skillset. Class is discussion based, and covers theoretical and practical pedagogical aspects to teaching in STEM. An integral feature of the course involves providing weekly tutoring sessions.
Rules & Requirements

Prerequisites: Prerequisite satisfied Concurrently: experience tutoring or as an academic intern; or concurrently serving as an academic intern while taking course

Hours & Format

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

Additional Details

Subject/Course Level: Computer Science/Professional course for teachers or prospective teachers

Grading: Letter grade.

Instructor: Hunn

COMPSCI 375 Teaching Techniques for Computer Science 2 Units

Terms offered: Fall 2025, Spring 2025, Fall 2024
Discussion and practice of techniques for effective teaching, focusing on issues most relevant to teaching assistants in computer science courses.
Rules & Requirements

Prerequisites: Consent of instructor

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

Hours & Format

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

Summer: 8 weeks - 4 hours of discussion per week

Additional Details

Subject/Course Level: Computer Science/Professional course for teachers or prospective teachers

Grading: Offered for satisfactory/unsatisfactory grade only.

Instructors: Barsky, Garcia, Harvey

COMPSCI 399 Professional Preparation: Supervised Teaching of Computer Science 1 or 2 Units

Terms offered: Spring 2020, Fall 2018, Fall 2016
Discussion, problem review and development, guidance of computer science laboratory sections, course development, supervised practice teaching.
Rules & Requirements

Prerequisites: Appointment as graduate student instructor

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

Hours & Format

Fall and/or spring: 15 weeks - 1-2 hours of independent study per week

Summer: 8 weeks - 1-2 hours of independent study per week

Additional Details

Subject/Course Level: Computer Science/Professional course for teachers or prospective teachers

Grading: Offered for satisfactory/unsatisfactory grade only.

COMPSCI 602 Individual Study for Doctoral Students 1 - 8 Units

Terms offered: Fall 2015, Fall 2014, Spring 2014
Individual study in consultation with the major field adviser, intended to provide an opportunity for qualified students to prepare themselves for the various examinations required of candidates for the Ph.D. (and other doctoral degrees).
Rules & Requirements

Credit Restrictions: Course does not satisfy unit or residence requirements for doctoral degree.

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

Hours & Format

Fall and/or spring: 15 weeks - 0 hours of independent study per week

Summer: 8 weeks - 6-45 hours of independent study per week

Additional Details

Subject/Course Level: Computer Science/Graduate examination preparation

Grading: Offered for satisfactory/unsatisfactory grade only.

Electrical Engineering and Computer Sciences

EL ENG 206A Introduction to Robotics 4 Units

Terms offered: Fall 2017, Fall 2016, Fall 2015
An introduction to the kinematics, dynamics, and control of robot manipulators, robotic vision, and sensing. The course will cover forward and inverse kinematics of serial chain manipulators, the manipulator Jacobian, force relations, dynamics and control-position, and force control. Proximity, tactile, and force sensing. Network modeling, stability, and fidelity in teleoperation and medical applications of robotics.
Rules & Requirements

Prerequisites: 120 or equivalent, or consent of instructor

Credit Restrictions: Students will receive no credit for 206A after taking C125/Bioengineering C125 or EE C106A

Hours & Format

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

Additional Details

Subject/Course Level: Electrical Engineering/Graduate

Grading: Letter grade.

Instructor: Bajcsy

Formerly known as: Electrical Engineering 215A

EL ENG 206B Robotic Manipulation and Interaction 4 Units

Terms offered: Spring 2018, Spring 2017
This course is a sequel to EECS 125/225, which covers kinematics, dynamics and control of a single robot. This course will cover dynamics and control of groups of robotic
manipulators coordinating with each other and interacting with the environment. Concepts will include
an introduction to grasping and the constrained manipulation, contacts and force control for interaction
with the environment. We will also cover active perception guided manipulation, as well as the
manipulation of non-rigid objects. Throughout, we will emphasize design and human-robot
interactions, and applications to applications in manufacturing, service robotics, tele-surgery, and
locomotion.
Objectives & Outcomes

Course Objectives: To teach students the connection between the geometry, physics of
manipulators with experimental setups that include sensors, control of large degrees of freedom
manipulators, mobile robots and different grippers.

Student Learning Outcomes: By the end of the course students will be able to build a complete
system composed of perceptual planning and autonomously controlled manipulators and /or
mobile systems, justified by predictive theoretical models of performance.

Rules & Requirements

Prerequisites: EL ENG 206A / BIO ENG C125; or consent of the instructor

Hours & Format

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

Additional Details

Subject/Course Level: Electrical Engineering/Graduate

Grading: Letter grade.

Instructors: Bajcsy, Sastry

EL ENG 210 Applied Electromagnetic Theory 3 Units

Terms offered: Fall 2025, Spring 2011, Spring 2010
Advanced treatment of classical electromagnetic theory with engineering applications. Boundary value problems in electrostatics. Applications of Maxwell's Equations to the study of waveguides, resonant cavities, optical fiber guides, Gaussian optics, diffraction, scattering, and antennas.

Rules & Requirements

Prerequisites: EL ENG 117; or PHYSICS 110A and PHYSICS 110B

Hours & Format

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

Additional Details

Subject/Course Level: Electrical Engineering/Graduate

Grading: Letter grade.

Formerly known as: 210A-210B

EL ENG 213A Power Electronics 4 Units

Terms offered: Fall 2025, Fall 2024, Fall 2023
Power conversion circuits and techniques. Characterization and design of magnetic devices including transformers, inductors, and electromagnetic actuators. Characteristics of power semiconductor devices, including power diodes, SCRs, MOSFETs, IGBTs, and emerging wide bandgap devices. Applications to renewable energy systems, high-efficiency lighting, power management in mobile electronics, and electric machine drives. Simulation based laboratory and design project.

Rules & Requirements

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

Hours & Format

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

Additional Details

Subject/Course Level: Electrical Engineering/Graduate

Grading: Letter grade.

Instructors: Pilawa, Boles

EL ENG 213B Power Electronics Design 4 Units

Terms offered: Spring 2025, Spring 2024
This course is the second in a two-semester series to equip students with the skills needed to analyze, design, and prototype power electronic converters. While EE 113/213A provides an overview of power electronics fundamentals and applications, EE 113B/213B focuses on the practical design and hardware implementation of power converters. The primary focus of EE 113B/213B is time in the laboratory, with sequential modules on topics such as power electronic components, PCB layout, closed-loop control, and experimental validation. At the end of the course, students will have designed, prototyped, and validated a power converter from scratch, demonstrating a skill set that is critical for power electronics engineers in research and industry.

Rules & Requirements

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

Hours & Format

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

Additional Details

Subject/Course Level: Electrical Engineering/Graduate

Grading: Letter grade.

Instructor: Boles

EL ENG C213 X-rays and Extreme Ultraviolet Radiation 3 Units

Terms offered: Spring 2025, Spring 2022, Spring 2021, Fall 2019
This course explores modern developments in the physics and applications of x-rays and extreme ultraviolet (EUV) radiation. It begins with a review of electromagnetic radiation at short wavelengths including dipole radiation, scattering and refractive index, using a semi-classical atomic model. Subject matter includes the generation of x-rays with synchrotron radiation, high harmonic generation, x-ray free electron lasers, laser-plasma sources. Spatial and temporal coherence concepts are explained. Optics appropriate for this spectral region are described. Applications include nanoscale and astrophysical imaging, femtosecond and attosecond probing of electron dynamics in molecules and solids, EUV lithography, and materials characteristics.

Rules & Requirements

Prerequisites: Physics 110, 137, and Mathematics 53, 54 or equivalent

Hours & Format

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

Additional Details

Subject/Course Level: Electrical Engineering/Graduate

Grading: Letter grade.

Instructor: Attwood

Also listed as: AST C210

EL ENG 218A Introduction to Optical Engineering 4 Units

Terms offered: Fall 2025, Fall 2024, Fall 2023
Fundamental principles of optical systems. Geometrical optics and aberration theory. Stops and apertures, prisms, and mirrors. Diffraction and interference. Optical materials and coatings. Radiometry and photometry. Basic optical devices and the human eye. The design of optical systems. Lasers, fiber optics, and holography.
Rules & Requirements

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

Credit Restrictions: Students will receive no credit for Electrical Engineering 218A after taking Electrical Engineering 118 or 119.

Hours & Format

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

Additional Details

Subject/Course Level: Electrical Engineering/Graduate

Grading: Letter grade.

Instructors: Waller, Kante

EL ENG 219B Logic Synthesis 4 Units

Terms offered: Spring 2016, Spring 2015, Spring 2011
The course covers the fundamental techniques for the design and analysis of digital circuits. The goal is to provide a detailed understanding of basic logic synthesis and analysis algorithms, and to enable students to apply this knowledge in the design of digital systems and EDA tools. The course will present combinational circuit optimization (two-level and multi-level synthesis), sequential circuit optimization (state encoding, retiming), timing analysis, testing, and logic verification.
Rules & Requirements

Prerequisites: Consent of instructor

Hours & Format

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

Additional Details

Subject/Course Level: Electrical Engineering/Graduate

Grading: Letter grade.

EL ENG C220A Advanced Control Systems I 3 Units

Terms offered: Fall 2025, Fall 2024, Fall 2023
Input-output and state space representation of linear continuous and discrete time dynamic systems. Controllability, observability, and stability. Modeling and identification. Design and analysis of single and multi-variable feedback control systems in transform and time domain. State observer. Feedforward/preview control. Application to engineering systems.
Rules & Requirements

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

Hours & Format

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

Additional Details

Subject/Course Level: Electrical Engineering/Graduate

Grading: Letter grade.

Instructors: Borrelli, Horowitz, Tomizuka, Tomlin

Also listed as: MEC ENG C232

EL ENG C220B Experiential Advanced Control Design I 3 Units

Terms offered: Fall 2025, Fall 2024, Fall 2023
Experience-based learning in the design of SISO and MIMO feedback controllers for linear systems. The student will master skills needed to apply linear control design and analysis tools to classical and modern control problems. In particular, the participant will be exposed to and develop expertise in two key control design technologies: frequency-domain control synthesis and time-domain optimization-based approach.
Hours & Format

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

Additional Details

Subject/Course Level: Electrical Engineering/Graduate

Grading: Letter grade.

Also listed as: MEC ENG C231A

EL ENG C220C Experiential Advanced Control Design II 3 Units

Terms offered: Spring 2025, Spring 2024, Spring 2023
Experience-based learning in design, analysis, & verification of automatic control for uncertain systems. The course emphasizes use of practical algorithms, including thorough computer implementation for representative problems. The student will master skills needed to apply advanced model-based control analysis, design, and estimation to a variety of industrial applications. First-principles analysis is provided to explain and support the algorithms & methods. The course emphasizes model-based state estimation, including the Kalman filter, and particle filter. Optimal feedback control of uncertain systems is also discussed (the linear quadratic Gaussian problem) as well as considerations of transforming continuous-time to discrete time.

Rules & Requirements

Prerequisites: Undergraduate controls course (e.g. MECENG 132, ELENG 128) Recommended: MECENG C231A/ELENG C220B and either MECENG C232/ELENG C220A or ELENG 221A

Hours & Format

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

Additional Details

Subject/Course Level: Electrical Engineering/Graduate

Grading: Letter grade.

Instructor: Mueller

Also listed as: MEC ENG C231B

EL ENG C220D Input/Output Methods for Compositional System Analysis 2 Units

Terms offered: Prior to 2007
Introduction to input/output concepts from control theory, systems as operators in signal spaces, passivity and
small-gain theorems, dissipativity theory, integral quadratic constraints. Compositional stabilility and
performance certification for interconnected systems from subsystems input/output properties. Case studies in
multi-agent systems, biological networks, Internet congestion control, and adaptive control.

Objectives & Outcomes

Course Objectives: Standard computational tools for control synthesis and verification do not scale well to large-scale, networked
systems in emerging applications. This course presents a compositional methodology suitable when the
subsystems are amenable to analytical and computational methods but the interconnection, taken as a whole, is
beyond the reach of these methods. The main idea is to break up the task of certifying desired stability and
performance properties into subproblems of manageable size using input/output properties. Students learn about
the fundamental theory, as well as relevant algorithms and applications in several domains.

Hours & Format

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

Additional Details

Subject/Course Level: Electrical Engineering/Graduate

Grading: Letter grade.

Instructors: Arcak, Packard

Also listed as: MEC ENG C220D

EL ENG 221A Linear System Theory 4 Units

Terms offered: Fall 2025, Fall 2024, Fall 2023
Basic system concepts; state-space and I/O representation. Properties of linear systems. Controllability, observability, minimality, state and output-feedback. Stability. Observers. Characteristic polynomial. Nyquist test.

Rules & Requirements

Prerequisites: EL ENG 120; and MATH 110 recommended

Hours & Format

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

Additional Details

Subject/Course Level: Electrical Engineering/Graduate

Grading: Letter grade.

EL ENG 222 Nonlinear Systems--Analysis, Stability and Control 3 Units

Terms offered: Spring 2017, Spring 2016, Spring 2015
Basic graduate course in non-linear systems. Second Order systems. Numerical solution methods, the describing function method, linearization. Stability - direct and indirect methods of Lyapunov. Applications to the Lure problem - Popov, circle criterion. Input-Output stability. Additional topics include: bifurcations of dynamical systems, introduction to the "geometric" theory of control for nonlinear systems, passivity concepts and dissipative dynamical systems.

Rules & Requirements

Prerequisites: EL ENG 221A (may be taken concurrently)

Hours & Format

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

Additional Details

Subject/Course Level: Electrical Engineering/Graduate

Grading: Letter grade.

EL ENG C222 Nonlinear Systems 3 Units

Terms offered: Spring 2025, Spring 2023, Spring 2022, Spring 2021
Basic graduate course in nonlinear systems. Nonlinear phenomena, planar systems, bifurcations, center manifolds, existence and uniqueness theorems. Lyapunov's direct and indirect methods, Lyapunov-based feedback stabilization. Input-to-state and input-output stability, and dissipativity theory. Computation techniques for nonlinear system analysis and design. Feedback linearization and sliding mode control methods.

Rules & Requirements

Prerequisites: MATH 54 (undergraduate level ordinary differential equations and linear algebra)

Hours & Format

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

Additional Details

Subject/Course Level: Electrical Engineering/Graduate

Grading: Letter grade.

Instructors: Arcak, Tomlin, Kameshwar

Also listed as: MEC ENG C237

EL ENG 223 Stochastic Systems: Estimation and Control 3 Units

Terms offered: Spring 2025, Spring 2024, Fall 2022
Parameter and state estimation. System identification. Nonlinear filtering. Stochastic control. Adaptive control.

Rules & Requirements

Prerequisites: EL ENG 226A (which students are encouraged to take concurrently)

Hours & Format

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

Additional Details

Subject/Course Level: Electrical Engineering/Graduate

Grading: Letter grade.

EL ENG 224A Digital Communications 4 Units

Terms offered: Fall 2010, Fall 2009, Fall 2008
Introduction to the basic principles of the design and analysis of modern digital communication systems. Topics include source coding; channel coding; baseband and passband modulation techniques; receiver design; channel equalization; information theoretic techniques; block, convolutional, and trellis coding techniques; multiuser communications and spread spectrum; multi-carrier techniques and FDM; carrier and symbol synchronization. Applications to design of digital telephone modems, compact disks, and digital wireless communication systems are illustrated. The concepts are illustrated by a sequence of MATLAB exercises.

Rules & Requirements

Prerequisites: EL ENG 120 and EL ENG 126

Hours & Format

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

Additional Details

Subject/Course Level: Electrical Engineering/Graduate

Grading: Letter grade.

Formerly known as: 224

EL ENG 224B Fundamentals of Wireless Communication 3 Units

Terms offered: Spring 2013, Spring 2012, Spring 2010
Introduction of the fundamentals of wireless communication. Modeling of the wireless multipath fading channel and its basic physical parameters. Coherent and noncoherent reception. Diversity techniques over time, frequency, and space. Spread spectrum communication. Multiple access and interference management in wireless networks. Frequency re-use, sectorization. Multiple access techniques: TDMA, CDMA, OFDM. Capacity of wireless channels. Opportunistic communication. Multiple antenna systems: spatial multiplexing, space-time codes. Examples from existing wireless standards.

Rules & Requirements

Prerequisites: EL ENG 121 and EL ENG 226A

Hours & Format

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

Additional Details

Subject/Course Level: Electrical Engineering/Graduate

Grading: Letter grade.

Instructor: Tse

EL ENG 225D Audio Signal Processing in Humans and Machines 3 Units

Terms offered: Fall 2024, Fall 2023, Fall 2022
Introduction to relevant signal processing and basics of pattern recognition. Introduction to coding, synthesis, and recognition. Models of speech and music production and perception. Signal processing for speech analysis. Pitch perception and auditory spectral analysis with applications to speech and music. Vocoders and music synthesizers. Statistical speech recognition, including introduction to Hidden Markov Model and Neural Network approaches.

Rules & Requirements

Prerequisites: EL ENG 123 and STAT 200A; or graduate standing and consent of instructor

Hours & Format

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

Additional Details

Subject/Course Level: Electrical Engineering/Graduate

Grading: Letter grade.

Instructor: Morgan

EL ENG C225E Principles of Magnetic Resonance Imaging 4 Units

Terms offered: Spring 2025, Spring 2023, Spring 2021
Fundamentals of MRI including signal-to-noise ratio, resolution, and contrast as dictated by physics, pulse sequences, and instrumentation. Image reconstruction via 2D FFT methods. Fast imaging reconstruction via convolution-back projection and gridding methods and FFTs. Hardware for modern MRI scanners including main field, gradient fields, RF coils, and shim supplies. Software for MRI including imaging methods such as 2D FT, RARE, SSFP, spiral and echo planar imaging methods.

Objectives & Outcomes

Course Objectives: Graduate level understanding of physics, hardware, and systems engineering description of image formation, and image reconstruction in MRI. Experience in Imaging with different MR Imaging systems. This course should enable students to begin graduate level research at Berkeley (Neuroscience labs, EECS and Bioengineering), LBNL or at UCSF (Radiology and Bioengineering) at an advanced level and make research-level contribution

Rules & Requirements

Prerequisites: EL ENG 120 or BIO ENG C165/EL ENG C145B or consent of instructor

Credit Restrictions: Students will receive no credit for Bioengineering C265/El Engineering C225E after taking El Engineering 265.

Repeat rules: Course may be repeated for credit under special circumstances: Students can only receive credit for 1 of the 2 versions of the class,BioEc265 or EE c225e, not both

Hours & Format

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

Additional Details

Subject/Course Level: Electrical Engineering/Graduate

Grading: Letter grade.

Instructors: Conolly, Vandsburger

Also listed as: BIO ENG C265/NUC ENG C235

EL ENG 226A Random Processes in Systems 4 Units

Terms offered: Fall 2025, Fall 2024, Spring 2024
Probability, random variables and their convergence, random processes. Filtering of wide sense stationary processes, spectral density, Wiener and Kalman filters. Markov processes and Markov chains. Gaussian, birth and death, poisson and shot noise processes. Elementary queueing analysis. Detection of signals in Gaussian and shot noise, elementary parameter estimation.

Rules & Requirements

Prerequisites: EL ENG 120 and STAT 200A

Hours & Format

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

Additional Details

Subject/Course Level: Electrical Engineering/Graduate

Grading: Letter grade.

Instructor: Anantharam

Formerly known as: 226

EL ENG 226B Applications of Stochastic Process Theory 2 Units

Terms offered: Spring 2017, Spring 2013, Spring 1997
Advanced topics such as: Martingale theory, stochastic calculus, random fields, queueing networks, stochastic control.

Rules & Requirements

Prerequisites: EL ENG 226A

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

Hours & Format

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

Additional Details

Subject/Course Level: Electrical Engineering/Graduate

Grading: Letter grade.

Instructors: Anantharam, Varaiya

EL ENG 227BT Convex Optimization 4 Units

Terms offered: Fall 2024, Fall 2023, Fall 2022
Convex optimization is a class of nonlinear optimization problems where the objective to be minimized, and the constraints, are both convex. The course covers some convex optimization theory and algorithms, and describes various applications arising in engineering design, machine learning and statistics, finance, and operations research. The course includes laboratory assignments, which consist of hands-on experiments with the optimization software CVX, and a discussion section.

Rules & Requirements

Prerequisites: MATH 54 and STAT 2

Hours & Format

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

Additional Details

Subject/Course Level: Electrical Engineering/Graduate

Grading: Letter grade.

Instructors: El Ghaoui, Wainwright

EL ENG C227C Convex Optimization and Approximation 3 Units

Terms offered: Spring 2022, Spring 2021, Spring 2020, Spring 2019, Spring 2018, Spring 2017
Convex optimization as a systematic approximation tool for hard decision problems. Approximations of combinatorial optimization problems, of stochastic programming problems, of robust optimization problems (i.e., with optimization problems with unknown but bounded data), of optimal control problems. Quality estimates of the resulting approximation. Applications in robust engineering design, statistics, control, finance, data mining, operations research.

Rules & Requirements

Prerequisites: 227A or consent of instructor

Hours & Format

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

Additional Details

Subject/Course Level: Electrical Engineering/Graduate

Grading: Letter grade.

Instructor: El Ghaoui

Also listed as: IND ENG C227B

EL ENG C227T Introduction to Convex Optimization 4 Units

Terms offered: Prior to 2007
The course covers some convex optimization theory and algorithms, and describes various applications arising in engineering design, machine learning and statistics, finance, and operations research. The course includes laboratory assignments, which consist of hands-on experience.
Hours & Format

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

Additional Details

Subject/Course Level: Electrical Engineering/Graduate

Grading: Letter grade.

Instructors: El Ghaoui, Wainwright

Formerly known as: Electrical Engineering C227A/Industrial Engin and Oper Research C227A

Also listed as: IND ENG C227A

EL ENG 228A High Speed Communications Networks 3 Units

Terms offered: Fall 2014, Spring 2014, Fall 2011
Descriptions, models, and approaches to the design and management of networks. Optical transmission and switching technologies are described and analyzed using deterministic, stochastic, and simulation models. FDDI, DQDB, SMDS, Frame Relay, ATM, networks, and SONET. Applications demanding high-speed communication.
Rules & Requirements

Prerequisites: EL ENG 122; and EL ENG 226A (may be taken concurrently)

Hours & Format

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

Additional Details

Subject/Course Level: Electrical Engineering/Graduate

Grading: Letter grade.

EL ENG 229A Information Theory and Coding 3 Units

Terms offered: Fall 2025, Fall 2024, Fall 2022
Fundamental bounds of Shannon theory and their application. Source and channel coding theorems. Galois field theory, algebraic error-correction codes. Private and public-key cryptographic systems.
Rules & Requirements

Prerequisites: STAT 200A; and EL ENG 226 recommended

Hours & Format

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

Additional Details

Subject/Course Level: Electrical Engineering/Graduate

Grading: Letter grade.

Instructors: Anantharam, Tse

Formerly known as: 229

EL ENG 229B Error Control Coding 3 Units

Terms offered: Spring 2019, Spring 2016, Fall 2013
Error control codes are an integral part of most communication and recording systems where they are primarily used to provide resiliency to noise. In this course, we will cover the basics of error control coding for reliable digital transmission and storage. We will discuss the major classes of codes that are important in practice, including Reed Muller codes, cyclic codes, Reed Solomon codes, convolutional codes, concatenated codes, turbo codes, and low density parity check codes. The relevant background material from finite field and polynomial algebra will be developed as part of the course. Overview of topics: binary linear block codes; Reed Muller codes; Galois fields; linear block codes over a finite field; cyclic codes; BCH and Reed Solomon codes; convolutional codes and trellis based decoding, message passing decoding algorithms; trellis based soft decision decoding of block codes; turbo codes; low density parity check codes.
Rules & Requirements

Prerequisites: 126 or equivalent (some familiarity with basic probability). Prior exposure to information theory not necessary

Hours & Format

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

Additional Details

Subject/Course Level: Electrical Engineering/Graduate

Grading: Letter grade.

Instructor: Anatharam

EL ENG 230A Integrated-Circuit Devices 4 Units

Terms offered: Fall 2025, Spring 2025, Fall 2024
Overview of electronic properties of semiconductors. Metal-semiconductor contacts, pn junctions, bipolar transistors, and MOS field-effect transistors. Properties that are significant to device operation for integrated circuits. Silicon device fabrication technology.
Rules & Requirements

Prerequisites: EECS 16A AND EECS 16B

Credit Restrictions: Students will receive no credit for EL ENG 230A after completing EL ENG 130, EL ENG 230M, or EL ENG W230A. A deficient grade in EL ENG 230A may be removed by taking EL ENG W230A.

Hours & Format

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

Additional Details

Subject/Course Level: Electrical Engineering/Graduate

Grading: Letter grade.

Formerly known as: Electrical Engineering 230M

EL ENG 230B Solid State Devices 4 Units

Terms offered: Fall 2020, Spring 2019, Spring 2018
Physical principles and operational characteristics of semiconductor devices. Emphasis is on MOS field-effect transistors and their behaviors dictated by present and probable future technologies. Metal-oxide-semiconductor systems, short-channel and high field effects, device modeling, and impact on analog, digital circuits.
Rules & Requirements

Prerequisites: EL ENG 130

Credit Restrictions: Students will receive no credit for EL ENG 230B after completing EL ENG 231, or EL ENG W230B. A deficient grade in EL ENG 230B may be removed by taking EL ENG W230B.

Hours & Format

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

Additional Details

Subject/Course Level: Electrical Engineering/Graduate

Grading: Letter grade.

Instructors: Subramanian, King Liu, Salahuddin

Formerly known as: Electrical Engineering 231

EL ENG 230C Solid State Electronics 3 Units

Terms offered: Fall 2025, Fall 2024, Fall 2023
Crystal structure and symmetries. Energy-band theory. Cyclotron resonance. Tensor effective mass. Statistics of electronic state population. Recombination theory. Carrier transport theory. Interface properties. Optical processes and properties.
Rules & Requirements

Prerequisites: EL ENG 131; and PHYSICS 137B

Hours & Format

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

Additional Details

Subject/Course Level: Electrical Engineering/Graduate

Grading: Letter grade.

Instructors: Bokor, Salahuddin

Formerly known as: Electrical Engineering 230

EL ENG W230A Integrated-Circuit Devices 4 Units

Terms offered: Spring 2019, Spring 2018, Spring 2017
Overview of electronic properties of semiconductors. Metal-semiconductor contacts, pn junctions, bipolar transistors, and MOS field-effect transistors. Properties that are significant to device operation for integrated circuits. Silicon device fabrication technology.
Rules & Requirements

Prerequisites: MAS-IC students only

Credit Restrictions: Students will receive no credit for Electrical Engineering W230A after taking Electrical Engineering 130, Electrical Engineering W130 or Electrical Engineering 230A.

Hours & Format

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

Summer: 10 weeks - 4.5 hours of web-based lecture and 1.5 hours of web-based discussion per week

Online: This is an online course.

Additional Details

Subject/Course Level: Electrical Engineering/Graduate

Grading: Letter grade.

Instructors: Javey, Subramanian, King Liu

Formerly known as: Electrical Engineering W130

EL ENG W230B Solid State Devices 4 Units

Terms offered: Fall 2015
Physical principles and operational characteristics of semiconductor devices. Emphasis is on MOS field-effect transistors and their behaviors dictated by present and probable future technologies. Metal-oxide-semiconductor systems, short-channel and high field effects, device modeling, and impact on analog, digital circuits.
Rules & Requirements

Prerequisites: EL ENG W230A; MAS-IC students only

Credit Restrictions: Students will receive no credit for EE W230B after taking EE 230B.

Hours & Format

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

Summer: 10 weeks - 4.5 hours of web-based lecture and 1.5 hours of web-based discussion per week

Online: This is an online course.

Additional Details

Subject/Course Level: Electrical Engineering/Graduate

Grading: Letter grade.

Instructors: Subramanian, King Liu, Salahuddin

Formerly known as: Electrical Engineering W231

EL ENG 232 Lightwave Devices 4 Units

Terms offered: Fall 2025, Spring 2025, Spring 2024
This course is designed to give an introduction and overview of the fundamentals of optoelectronic devices. Topics such as optical gain and absorption spectra, quantization effects, strained quantum wells, optical waveguiding and coupling, and hetero p-n junction will be covered. This course will focus on basic physics and design principles of semiconductor diode lasers, light emitting diodes, photodetectors and integrated optics. Practical applications of the devices will be also discussed.
Rules & Requirements

Prerequisites: EL ENG 130; PHYSICS 137A; and EL ENG 117 recommended

Hours & Format

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

Additional Details

Subject/Course Level: Electrical Engineering/Graduate

Grading: Letter grade.

Instructor: Wu

EL ENG 234A Fundamentals of Photovoltaic Devices 4 Units

Terms offered: Spring 2025
This course is designed to give an introduction, and overview of, the fundamentals of photovoltaic devices. Students will learn how solar cells work, understand the concepts and models of
solar cell device physics, and formulate and solve relevant physical problems related to photovoltaic devices. Monocrystalline, thin film and third generation solar cells will be discussed and analyzed. Light management and economic considerations in a solar cell system will also be covered.
Rules & Requirements

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

Hours & Format

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

Additional Details

Subject/Course Level: Electrical Engineering/Graduate

Grading: Letter grade.

Instructor: Arias

EL ENG C235 Nanoscale Fabrication 4 Units

Terms offered: Spring 2025, Spring 2024, Spring 2023, Spring 2016, Spring 2015, Spring 2013
This course discusses various top-down and bottom-up approaches to synthesizing and processing nanostructured materials. The topics include fundamentals of self assembly, nano-imprint lithography, electron beam lithography, nanowire and nanotube synthesis, quantum dot synthesis (strain patterned and colloidal), postsynthesis modification (oxidation, doping, diffusion, surface interactions, and etching techniques). In addition, techniques to bridging length scales such as heterogeneous integration will be discussed. We will discuss new electronic, optical, thermal, mechanical, and chemical properties brought forth by the very small sizes.
Hours & Format

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

Additional Details

Subject/Course Level: Electrical Engineering/Graduate

Grading: Letter grade.

Instructor: Chang-Hasnain

Also listed as: NSE C203

EL ENG 236A Quantum and Optical Electronics 3 Units

Terms offered: Fall 2025, Fall 2023, Fall 2022
Interaction of radiation with atomic and semiconductor systems, density matrix treatment, semiclassical laser theory (Lamb's), laser resonators, specific laser systems, laser dynamics, Q-switching and mode-locking, noise in lasers and optical amplifiers. Nonlinear optics, phase-conjugation, electrooptics, acoustooptics and magnetooptics, coherent optics, stimulated Raman and Brillouin scattering.
Rules & Requirements

Prerequisites: EL ENG 117A and PHYSICS 137A

Hours & Format

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

Additional Details

Subject/Course Level: Electrical Engineering/Graduate

Grading: Letter grade.

EL ENG C239 Partially Ionized Plasmas 3 Units

Terms offered: Spring 2010, Spring 2009, Spring 2007
Introduction to partially ionized, chemically reactive plasmas, including collisional processes, diffusion, sources, sheaths, boundaries, and diagnostics. DC, RF, and microwave discharges. Applications to plasma-assisted materials processing and to plasma wall interactions.
Rules & Requirements

Prerequisites: An upper division course in electromagnetics or fluid dynamics

Hours & Format

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

Additional Details

Subject/Course Level: Electrical Engineering/Graduate

Grading: Letter grade.

Formerly known as: 239

Also listed as: AST C239

EL ENG 240A Analog Integrated Circuits 4 Units

Terms offered: Fall 2025, Spring 2025, Fall 2024
Single and multiple stage transistor amplifiers. Operational amplifiers. Feedback amplifiers, 2-port formulation, source, load, and feedback network loading. Frequency response of cascaded amplifiers, gain-bandwidth exchange, compensation, dominant pole techniques, root locus. Supply and temperature independent biasing and references. Selected applications of analog circuits such as analog-to-digital converters, switched capacitor filters, and comparators. Hardware laboratory and design project.
Rules & Requirements

Prerequisites: EL ENG 105

Credit Restrictions: Students will receive no credit for EL ENG 240A after completing EL ENG 140, or EL ENG W240A. A deficient grade in EL ENG 240A may be removed by taking EL ENG W240A.

Hours & Format

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

Additional Details

Subject/Course Level: Electrical Engineering/Graduate

Grading: Letter grade.

Instructors: Sanders, Nguyen

EL ENG 240B Advanced Analog Integrated Circuits 4 Units

Terms offered: Spring 2025, Spring 2024, Spring 2023
Analysis and optimized design of monolithic operational amplifiers and wide-band amplifiers; methods of achieving wide-band amplification, gain-bandwidth considerations; analysis of noise in integrated circuits and low noise design. Precision passive elements, analog switches, amplifiers and comparators, voltage reference in NMOS and CMOS circuits, Serial, successive-approximation, and parallel analog-to-digital converters. Switched-capacitor and CCD filters. Applications to codecs, modems.
Rules & Requirements

Prerequisites: EL ENG 140 / EL ENG 240A

Credit Restrictions: Students will receive no credit for EL ENG 240B after completing EL ENG 240, or EL ENG W240B. A deficient grade in EL ENG 240B may be removed by taking EL ENG W240B.

Hours & Format

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

Additional Details

Subject/Course Level: Electrical Engineering/Graduate

Grading: Letter grade.

EL ENG 240C Analysis and Design of VLSI Analog-Digital Interface Integrated Circuits 3 Units

Terms offered: Fall 2024, Spring 2023, Fall 2019
Architectural and circuit level design and analysis of integrated analog-to-digital and digital-to-analog interfaces in CMOS and BiCMOS VLSI technology. Analog-digital converters, digital-analog converters, sample/hold amplifiers, continuous and switched-capacitor filters. RF integrated electronics including synthesizers, LNA's, and baseband processing. Low power mixed signal design. Data communications functions including clock recovery. CAD tools for analog design including simulation and synthesis.

Rules & Requirements

Prerequisites: EL ENG 140

Credit Restrictions: Students will receive no credit for EL ENG 240C after completing EL ENG 290Y, or EL ENG W240C. A deficient grade in EL ENG 240C may be removed by taking EL ENG W240C.

Hours & Format

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

Additional Details

Subject/Course Level: Electrical Engineering/Graduate

Grading: Letter grade.

Instructor: Boser

Formerly known as: Electrical Engineering 247

EL ENG W240A Analog Integrated Circuits 4 Units

Terms offered: Spring 2020, Spring 2019, Spring 2018
Single and multiple stage transistor amplifiers. Operational amplifiers. Feedback amplifiers, 2-port formulation, source, load, and feedback network loading. Frequency response of cascaded amplifiers, gain-bandwidth exchange, compensation, dominant pole techniques, root locus. Supply and temperature independent biasing and references. Selected applications of analog circuits such as analog-to-digital converters, switched capacitor filters, and comparators.

Rules & Requirements

Prerequisites: MAS-IC students only

Credit Restrictions: Students will receive no credit for EE W240A after taking EE 140 or EE 240A.

Hours & Format

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

Summer: 10 weeks - 4.5 hours of web-based lecture and 1.5 hours of web-based discussion per week

Online: This is an online course.

Additional Details

Subject/Course Level: Electrical Engineering/Graduate

Grading: Letter grade.

Instructors: Alon, Sanders, Nguyen

EL ENG W240B Advanced Analog Integrated Circuits 3 Units

Terms offered: Spring 2020, Spring 2019, Fall 2015
Analysis and optimized design of monolithic operational amplifiers and wide-band amplifiers; methods of achieving wide-band amplification, gain-bandwidth considerations; analysis of noise in integrated circuits and low noise design. Precision passive elements, analog switches, amplifiers and comparators, voltage reference in NMOS and CMOS circuits, Serial, successive-approximation, and parallel analog-to-digital converts. Switched-capacitor and CCD filters. Applications to codecs, modems.

Rules & Requirements

Prerequisites: EL ENG W240A; MAS-IC students only

Credit Restrictions: Students will receive no credit for EE W240B after taking EE 240B.

Hours & Format

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

Summer: 10 weeks - 4.5 hours of web-based lecture per week

Online: This is an online course.

Additional Details

Subject/Course Level: Electrical Engineering/Graduate

Grading: Letter grade.

Formerly known as: Electrical Engineering W240

EL ENG W240C Analysis and Design of VLSI Analog-Digital Interface Integrated Circuits 3 Units

Terms offered: Spring 2017, Spring 2016
Architectural and circuit level design and analysis of integrated analog-to-digital and digital-to-analog interfaces in modern CMOS and BiCMOS VLSI technology. Analog-digital converters, digital-analog converters, sample/hold amplifiers, continuous and switched-capacitor filters. Low power mixed signal design techniques. Data communications systems including interface circuity. CAD tools for analog design for simulation and synthesis.

Rules & Requirements

Prerequisites: EL ENG W240A; MAS-IC students only

Credit Restrictions: Students will receive no credit for EE W240C after taking EE 240C.

Hours & Format

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

Summer: 10 weeks - 4.5 hours of web-based lecture per week

Online: This is an online course.

Additional Details

Subject/Course Level: Electrical Engineering/Graduate

Grading: Letter grade.

Instructor: Boser

Formerly known as: Electrical Engineering W247

EL ENG 241B Advanced Digital Integrated Circuits 3 Units

Terms offered: Spring 2021, Spring 2020, Spring 2019
Analysis and design of MOS and bipolar large-scale integrated circuits at the circuit level. Fabrication processes, device characteristics, parasitic effects static and dynamic digital circuits for logic and memory functions. Calculation of speed and power consumption from layout and fabrication parameters. ROM, RAM, EEPROM circuit design. Use of SPICE and other computer aids.

Rules & Requirements

Prerequisites: EL ENG 141

Credit Restrictions: Students will receive no credit for EL ENG 241B after completing EL ENG 241, or EL ENG W241B. A deficient grade in EL ENG 241B may be removed by taking EL ENG W241B.

Hours & Format

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

Additional Details

Subject/Course Level: Electrical Engineering/Graduate

Grading: Letter grade.

Instructors: Nikolic, Rabaey

Formerly known as: Electrical Engineering 241

EL ENG W241A Introduction to Digital Integrated Circuits 4 Units

Terms offered: Fall 2015, Fall 2014, Spring 2014
CMOS devices and deep sub-micron manufacturing technology. CMOS inverters and complex gates. Modeling of interconnect wires. Optimization of designs with respect to a number of metrics: cost, reliability, performance, and power dissipation. Sequential circuits, timing considerations, and clocking approaches. Design of large system blocks, including arithmetic, interconnect, memories, and programmable logic arrays. Introduction to design methodologies, including laboratory experience.

Rules & Requirements

Prerequisites: MAS-IC students only

Credit Restrictions: Students will receive no credit for W241A after taking EE 141 or EE 241A.

Hours & Format

Fall and/or spring: 15 weeks - 3 hours of web-based lecture and 4 hours of web-based discussion per week

Summer: 10 weeks - 4.5 hours of web-based lecture and 6 hours of web-based discussion per week

Online: This is an online course.

Additional Details

Subject/Course Level: Electrical Engineering/Graduate

Grading: Letter grade.

Instructors: Alon, Rabaey, Nikolic

EL ENG W241B Advanced Digital Integrated Circuits 3 Units

Terms offered: Spring 2017, Spring 2016, Spring 2015
Analysis and design of MOS and bipolar large-scale integrated circuits at the circuit level. Fabrication processes, device characteristics, parasitic effects static and dynamic digital circuits for logic and memory functions. Calculation of speed and power consumption from layout and fabrication parameters. ROM, RAM, EEPROM circuit design. Use of SPICE and other computer aids.

Rules & Requirements

Prerequisites: EL ENG W241A; MAS-IC students only

Credit Restrictions: Students will receive no credit for EE W241B after taking EE 241B.

Hours & Format

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

Summer: 10 weeks - 4.5 hours of web-based lecture per week

Online: This is an online course.

Additional Details

Subject/Course Level: Electrical Engineering/Graduate

Grading: Letter grade.

Instructors: Nikolic, Rabaey

Formerly known as: Electrical Engineering W241

EL ENG 242A Integrated Circuits for Communications 4 Units

Terms offered: Spring 2025, Fall 2023, Spring 2023
Analysis and design of electronic circuits for communication systems, with an emphasis on integrated circuits for wireless communication systems. Analysis of noise and distortion in amplifiers with application to radio receiver design. Power amplifier design with application to wireless radio transmitters. Radio-frequency mixers, oscillators, phase-locked loops, modulators, and demodulators.

Rules & Requirements

Prerequisites: EL ENG 140/240A or equivalent

Credit Restrictions: Students will receive no credit for Electrical Engineering 242A after taking Electrical Engineering 142.

Hours & Format

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

Additional Details

Subject/Course Level: Electrical Engineering/Graduate

Grading: Letter grade.

Formerly known as: Electrical Engineering 242M

EL ENG 242B Advanced Integrated Circuits for Communications 3 Units

Terms offered: Fall 2024, Fall 2020, Fall 2014
Analysis, evaluation and design of present-day integrated circuits for communications application, particularly those for which nonlinear response must be included. MOS, bipolar and BICMOS circuits, audio and video power amplifiers, optimum performance of near-sinusoidal oscillators and frequency-translation circuits. Phase-locked loop ICs, analog multipliers and voltage-controlled oscillators; advanced components for telecommunication circuits. Use of new CAD tools and systems.

Rules & Requirements

Prerequisites: EL ENG 142 and EL ENG 240

Credit Restrictions: Students will receive no credit for EL ENG 242B after completing EL ENG 242, or EL ENG W242B. A deficient grade in EL ENG 242B may be removed by taking EL ENG W242B.

Hours & Format

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

Additional Details

Subject/Course Level: Electrical Engineering/Graduate

Grading: Letter grade.

Instructor: Niknejad

Formerly known as: Electrical Engineering 242

EL ENG W242A Integrated Circuits for Communications 4 Units

Terms offered: Spring 2020, Spring 2019, Spring 2018
Analysis and design of electronic circuits for communication systems, with an emphasis on integrated circuits for wireless communication systems. Analysis of noise and distortion in amplifiers with application to radio receiver design. Power amplifier design with application to wireless radio transmitters. Radio-frequency mixers, oscillators, phase-locked loops, modulators, and demodulators.

Rules & Requirements

Prerequisites: EL ENG W240A; MAS-IC students only

Credit Restrictions: Students will receive no credit for EE W242A after taking EE 142, EE 242A, or EE 242B.

Hours & Format

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

Summer: 10 weeks - 4.5 hours of web-based lecture and 1.5 hours of web-based discussion per week

Online: This is an online course.

Additional Details

Subject/Course Level: Electrical Engineering/Graduate

Grading: Letter grade.

Instructor: Niknejad

Formerly known as: Electrical Engineering W142

EL ENG W242B Advanced Integrated Circuits for Communications 3 Units

Terms offered: Spring 2017, Spring 2016
Analysis, evaluation, and design of present-day integrated circuits for communications application, particularly those for which nonlinear response must be included. MOS, bipolar and BICMOS circuits, audio and video power amplifiers, optimum performance of near-sinusoidal oscillators and frequency-translation circuits. Phase-locked loop ICs, analog multipliers and voltage-controlled oscillators; advanced components for telecommunication circuits. Use of new CAD tools and systems.

Rules & Requirements

Prerequisites: EL ENG W240A; EL ENG W242A; MAS-IC students only

Credit Restrictions: Students will receive no credit for EE W242B after taking EE 242B.

Hours & Format

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

Summer: 10 weeks - 4.5 hours of web-based lecture per week

Online: This is an online course.

Additional Details

Subject/Course Level: Electrical Engineering/Graduate

Grading: Letter grade.

Instructor: Niknejad

Formerly known as: Electrical Engineering W242

EL ENG 243 Advanced IC Processing and Layout 3 Units

Terms offered: Spring 2014, Spring 2012, Spring 2011
The key processes for the fabrication of integrated circuits. Optical, X-ray, and e-beam lithography, ion implantation, oxidation and diffusion. Thin film deposition. Wet and dry etching and ion milling. Effect of phase and defect equilibria on process control.

Rules & Requirements

Prerequisites: EL ENG 143; and either EL ENG 140 or EL ENG 141

Hours & Format

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

Additional Details

Subject/Course Level: Electrical Engineering/Graduate

Grading: Letter grade.

EL ENG 244 Fundamental Algorithms for Systems Modeling, Analysis, and Optimization 4 Units

Terms offered: Spring 2025, Fall 2016, Fall 2015
The modeling, analysis, and optimization of complex systems requires a range of algorithms and design software. This course reviews the fundamental techniques underlying the design methodology for complex systems, using integrated circuit design as example. Topics include design flows, discrete and continuous models and algorithms, and strategies for implementing algorithms efficiently and correctly in software. Laboratory assignments and a class project will expose students to state-of-the-art.

Rules & Requirements

Prerequisites: Graduate standing

Credit Restrictions: Students will receive no credit for EL ENG 244 after completing EL ENG W244.

Hours & Format

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

Additional Details

Subject/Course Level: Electrical Engineering/Graduate

Grading: Letter grade.

Instructors: Keutzer, Lee, Roychowdhury, Seshia

EL ENG W244 Fundamental Algorithms for System Modeling, Analysis, and Optimization 4 Units

Terms offered: Fall 2015
The modeling, analysis, and optimization of complex systems require a range of algorithms and design tools. This course reviews the fundamental techniques underlying the design methodology for complex systems, using integrated circuit design as an example. Topics include design flows, discrete and continuous models and algorithms, and strategies for implementing algorithms efficiently and correctly in software.

Rules & Requirements

Prerequisites: MAS-IC students only

Credit Restrictions: Students will receive no credit for W244 after taking 144 and 244.

Hours & Format

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

Summer: 10 weeks - 4.5 hours of web-based lecture per week

Online: This is an online course.

Additional Details

Subject/Course Level: Electrical Engineering/Graduate

Grading: Letter grade.

Instructors: Keutzer, Lee, Roychowdhury, Seshia

EL ENG C246 Parametric and Optimal Design of MEMS 3 Units

Terms offered: Spring 2013, Spring 2012, Spring 2011
Parametric design and optimal design of MEMS. Emphasis on design, not fabrication. Analytic solution of MEMS design problems to determine the dimensions of MEMS structures for specified function. Trade-off of various performance requirements despite conflicting design requirements. Structures include flexure systems, accelerometers, and rate sensors.

Rules & Requirements

Prerequisites: Graduate standing or consent of instructor

Hours & Format

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

Additional Details

Subject/Course Level: Electrical Engineering/Graduate

Grading: Letter grade.

Instructors: Lin, Pisano

Formerly known as: 219

Also listed as: MEC ENG C219

EL ENG 247A Introduction to Microelectromechanical Systems (MEMS) 3 Units

Terms offered: Fall 2025, Fall 2024, Fall 2023
This course will teach fundamentals of micromachining and microfabrication techniques, including planar thin-film process technologies, photolithographic techniques, deposition and etching techniques, and the other technologies that are central to MEMS fabrication. It will pay special attention to teaching of fundamentals necessary for the design and analysis of devices and systems in mechanical, electrical, fluidic, and thermal energy/signal domains, and will teach basic techniques for multi-domain analysis. Fundamentals of sensing and transduction mechanisms including capacitive and piezoresistive techniques, and design and analysis of micmicromachined miniature sensors and actuators using these techniques will be covered.

Rules & Requirements

Prerequisites: EECS 16A and EECS 16B; or consent of instructor required

Credit Restrictions: Students will receive no credit for EE 247A after taking EE 147.

Hours & Format

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

Additional Details

Subject/Course Level: Electrical Engineering/Graduate

Grading: Letter grade.

Instructors: Maharbiz, Nguyen, Pister

EL ENG C247B Introduction to MEMS Design 4 Units

Terms offered: Spring 2025, Spring 2024, Spring 2023, Spring 2022, Spring 2021
Physics, fabrication, and design of micro-electromechanical systems (MEMS). Micro and nanofabrication processes, including silicon surface and bulk micromachining and non-silicon micromachining. Integration strategies and assembly processes. Microsensor and microactuator devices: electrostatic, piezoresistive, piezoelectric, thermal, magnetic transduction. Electronic position-sensing circuits and electrical and mechanical noise. CAD for MEMS. Design project is required.
Rules & Requirements

Prerequisites: Graduate standing in engineering or science; undergraduates with consent of instructor

Hours & Format

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

Additional Details

Subject/Course Level: Electrical Engineering/Graduate

Grading: Letter grade.

Instructors: Nguyen, Pister

Formerly known as: Electrical Engineering C245, Mechanical Engineering C218

Also listed as: MEC ENG C218

EL ENG W247B Introduction to MEMS Design 4 Units

Terms offered: Prior to 2007
Physics, fabrication and design of micro electromechanical systems (MEMS). Micro and nano-fabrication processes, including silicon surface and bulk micromachining and non-silicon micromachining. Integration strategies and assembly processes. Microsensor and microactuator devices: electrostatic, piezoresistive, piezoelectric, thermal, and magnetic transduction. Electronic position-sensing circuits and electrical and mechanical noise. CAD for MEMS. Design project is required.
Rules & Requirements

Prerequisites: MAS-IC students only

Credit Restrictions: Students will receive no credit for EE W247B after taking EE C247B or Mechanical Engineering C218.

Hours & Format

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

Summer: 10 weeks - 4.5 hours of web-based lecture and 1.5 hours of web-based discussion per week

Online: This is an online course.

Additional Details

Subject/Course Level: Electrical Engineering/Graduate

Grading: Letter grade.

Instructors: Nguyen, Pister

Formerly known as: Electrical Engineering W245

EL ENG 248C Numerical Modeling and Analysis: Nonlinear Systems and Noise 4 Units

Terms offered: Prior to 2007
Numerical modelling and analysis techniques are widely used in scientific and
engineering practice; they are also an excellent vehicle for understanding and
concretizing theory.
This course covers topics important for a proper understanding of nonlinearity
and noise: periodic steady state and envelope ("RF") analyses; oscillatory
systems; nonstationary and phase noise; and homotopy/continuation techniques
for solving "difficult" equation systems. An underlying theme of the course is
relevance to different physical domains, from electronics (e.g., analog/RF/mixed-signal circuits, high-speed digital circuits, interconnect, etc.) to optics, nanotechnology, chemistry, biology and mechanics. Hands-on
coding using the MATLAB-based Berkeley Model
Objectives & Outcomes

Course Objectives: Homotopy techniques for robust nonlinear equation solution
Modelling and analysis of oscillatory systems
- harmonic, ring and relaxation oscillators
- oscillator steady state analysis
- perturbation analysis of amplitude-stable oscillators
RF (nonlinear periodic steady state) analysis
- harmonic balance and shooting
- Multi-time PDE and envelope methods
- perturbation analysis of periodic systems (Floquet theory)
RF (nonlinear, nonstationary) noise concepts and their application
- cyclostationary noise analysis
- concepts of phase noise in oscillators
Using MAPP for fast/convenient modelling and analysis

Student Learning Outcomes: Students will develop a facility in the above topics and be able to apply them
widely across science and engineering.

Rules & Requirements

Prerequisites: Consent of Instructor

Hours & Format

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

Additional Details

Subject/Course Level: Electrical Engineering/Graduate

Grading: Letter grade.

Instructor: Roychowdhury

EL ENG C249A Introduction to Embedded Systems 4 Units

Terms offered: Fall 2025, Fall 2024, Fall 2023
This course introduces students to the basics of models, analysis tools, and control for embedded systems operating in real time. Students learn how to combine physical processes with computation. Topics include models of computation, control, analysis and verification, interfacing with the physical world, mapping to platforms, and distributed embedded systems. The course has a strong laboratory component, with emphasis on a semester-long sequence of projects.
Rules & Requirements

Credit Restrictions: Students will receive no credit for Electrical Engineering/Computer Science C249A after completing Electrical Engineering/Computer Science C149.

Hours & Format

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

Additional Details

Subject/Course Level: Electrical Engineering/Graduate

Grading: Letter grade.

Instructors: Lee, Seshia

Formerly known as: Electrical Engineering C249M/Computer Science C249M

Also listed as: COMPSCI C249A

EL ENG C261 Medical Imaging Signals and Systems 4 Units

Terms offered: Fall 2025, Fall 2024, Fall 2023
Biomedical imaging is a clinically important application of engineering, applied mathematics, physics, and medicine. In this course, we apply linear systems theory and basic physics to analyze X-ray imaging, computerized tomography, nuclear medicine, and MRI. We cover the basic physics and instrumentation that characterizes medical image as an ideal perfect-resolution image blurred by an impulse response. This material could prepare the student for a career in designing new medical imaging systems that reliably detect small tumors or infarcts.
Objectives & Outcomes

Course Objectives: •
understand how 2D impulse response or 2D spatial frequency transfer function (or Modulation Transfer Function) allow one to quantify the spatial resolution of an imaging system.
•
understand 2D sampling requirements to avoid aliasing
•
understand 2D filtered backprojection reconstruction from projections based on the projection-slice theorem of Fourier Transforms
•
understand the concept of image reconstruction as solving a mathematical inverse problem.
•
understand the limitations of poorly conditioned inverse problems and noise amplification
•
understand how diffraction can limit resolution---but not for the imaging systems in this class
•
understand the hardware components of an X-ray imaging scanner
•
•
understand the physics and hardware limits to spatial resolution of an X-ray imaging system
•
understand tradeoffs between depth, contrast, and dose for X-ray sources
•
understand resolution limits for CT scanners
•
understand how to reconstruct a 2D CT image from projection data using the filtered backprojection algorithm
•
understand the hardware and physics of Nuclear Medicine scanners
•
understand how PET and SPECT images are created using filtered backprojection
•
understand resolution limits of nuclear medicine scanners
•
understand MRI hardware components, resolution limits and image reconstruction via a 2D FFT
•
understand how to construct a medical imaging scanner that will achieve a desired spatial resolution specification.

Student Learning Outcomes: •
students will be tested for their understanding of the key concepts above
•
undergraduate students will apply to graduate programs and be admitted
•
students will apply this knowledge to their research at Berkeley, UCSF

EL ENG 290 Advanced Topics in Electrical Engineering 1 - 4 Units

Terms offered: Fall 2025, Spring 2025, Fall 2024
The 290 courses cover current topics of research interest in electrical engineering. The course content may vary from semester to semester.
Rules & Requirements

Prerequisites: Consent of instructor

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

Hours & Format

Fall and/or spring:
4 weeks - 3-15 hours of lecture per week
6 weeks - 3-9 hours of lecture per week
8 weeks - 2-6 hours of lecture per week
10 weeks - 2-5 hours of lecture per week
15 weeks - 1-3 hours of lecture per week

Additional Details

Subject/Course Level: Electrical Engineering/Graduate

Grading: Letter grade.

EL ENG 290A Advanced Topics in Electrical Engineering: Advanced Topics in Computer-Aided Design 1 - 3 Units

Terms offered: Spring 2016, Spring 2015, Fall 2014
The 290 courses cover current topics of research interest in electrical engineering. The course content may vary from semester to semester.
Rules & Requirements

Prerequisites: Consent of instructor

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

Hours & Format

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

Additional Details

Subject/Course Level: Electrical Engineering/Graduate

Grading: Letter grade.

EL ENG 290B Advanced Topics in Electrical Engineering: Advanced Topics in Solid State Devices 1 - 3 Units

Terms offered: Spring 2021, Spring 2020, Spring 2019
The 290 courses cover current topics of research interest in electrical engineering. The course content may vary from semester to semester.
Rules & Requirements

Prerequisites: Consent of instructor

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

Hours & Format

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

Additional Details

Subject/Course Level: Electrical Engineering/Graduate

Grading: Letter grade.

EL ENG 290C Advanced Topics in Electrical Engineering: Advanced Topics in Circuit Design 1 - 3 Units

Terms offered: Spring 2019, Fall 2018, Spring 2018
The 290 courses cover current topics of research interest in electrical engineering. The course content may vary from semester to semester.
Rules & Requirements

Prerequisites: Consent of instructor

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

Hours & Format

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

Additional Details

Subject/Course Level: Electrical Engineering/Graduate

Grading: Letter grade.

EL ENG 290D Advanced Topics in Electrical Engineering: Advanced Topics in Semiconductor Technology 1 - 3 Units

Terms offered: Spring 2021, Fall 2014, Fall 2013
The 290 courses cover current topics of research interest in electrical engineering. The course content may vary from semester to semester.
Rules & Requirements

Prerequisites: Consent of instructor

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

Hours & Format

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

Additional Details

Subject/Course Level: Electrical Engineering/Graduate

Grading: Letter grade.

EL ENG 290F Advanced Topics in Electrical Engineering: Advanced Topics in Photonics 1 - 3 Units

Terms offered: Spring 2014, Fall 2013, Fall 2012
The 290 courses cover current topics of research interest in electrical engineering. The course content may vary from semester to semester.
Rules & Requirements

Prerequisites: Consent of instructor

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

Hours & Format

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

Additional Details

Subject/Course Level: Electrical Engineering/Graduate

Grading: Letter grade.

EL ENG 290G Advanced Topics in Electrical Engineering: Advanced Topics in Mems, Microsensors, and Microactuators 1 - 3 Units

Terms offered: Fall 2017, Fall 2016, Spring 2002
The 290 courses cover current topics of research interest in electrical engineering. The course content may vary from semester to semester.
Rules & Requirements

Prerequisites: Consent of instructor

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

Hours & Format

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

Additional Details

Subject/Course Level: Electrical Engineering/Graduate

Grading: Letter grade.

Formerly known as: Engineering 210

EL ENG 290N Advanced Topics in Electrical Engineering: Advanced Topics in System Theory 1 - 3 Units

Terms offered: Fall 2018, Fall 2017, Fall 2015
The 290 courses cover current topics of research interest in electrical engineering. The course content may vary from semester to semester.
Rules & Requirements

Prerequisites: Consent of instructor

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

Hours & Format

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

Additional Details

Subject/Course Level: Electrical Engineering/Graduate

Grading: Letter grade.

EL ENG 290O Advanced Topics in Electrical Engineering: Advanced Topics in Control 1 - 3 Units

Terms offered: Spring 2019, Fall 2018, Fall 2017
The 290 courses cover current topics of research interest in electrical engineering. The course content may vary from semester to semester.
Rules & Requirements

Prerequisites: Consent of instructor

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

Hours & Format

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

Additional Details

Subject/Course Level: Electrical Engineering/Graduate

Grading: Letter grade.

EL ENG 290P Advanced Topics in Electrical Engineering: Advanced Topics in Bioelectronics 1 - 3 Units

Terms offered: Spring 2019, Spring 2018, Fall 2017
The 290 courses cover current topics of research interest in electrical engineering. The course content may vary from semester to semester.
Rules & Requirements

Prerequisites: Consent of instructor

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

Hours & Format

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

Additional Details

Subject/Course Level: Electrical Engineering/Graduate

Grading: Letter grade.

EL ENG 290Q Advanced Topics in Electrical Engineering: Advanced Topics in Communication Networks 1 - 3 Units

Terms offered: Spring 2017, Spring 2016, Fall 2014
The 290 courses cover current topics of research interest in electrical engineering. The course content may vary from semester to semester.
Rules & Requirements

Prerequisites: Consent of instructor

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

Hours & Format

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

Additional Details

Subject/Course Level: Electrical Engineering/Graduate

Grading: Letter grade.

EL ENG 290S Advanced Topics in Electrical Engineering: Advanced Topics in Communications and Information Theory 1 - 3 Units

Terms offered: Fall 2018, Fall 2016, Fall 2009
The 290 courses cover current topics of research interest in electrical engineering. The course content may vary from semester to semester.
Rules & Requirements

Prerequisites: Consent of instructor

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

Hours & Format

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

Additional Details

Subject/Course Level: Electrical Engineering/Graduate

Grading: Letter grade.

EL ENG 290T Advanced Topics in Electrical Engineering: Advanced Topics in Signal Processing 1 - 3 Units

Terms offered: Fall 2018, Fall 2017, Fall 2016
The 290 courses cover current topics of research interest in electrical engineering. The course content may vary from semester to semester.
Rules & Requirements

Prerequisites: Consent of instructor

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

Hours & Format

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

Additional Details

Subject/Course Level: Electrical Engineering/Graduate

Grading: Letter grade.

EL ENG 290Y Advanced Topics in Electrical Engineering: Organic Materials in Electronics 3 Units

Terms offered: Spring 2014, Spring 2013, Fall 2009
Organic materials are seeing increasing application in electronics applications. This course will provide an overview of the properties of the major classes of organic materials with relevance to electronics. Students will study the technology, physics, and chemistry of their use in the three most rapidly growing major applications--energy conversion/generation devices (fuel cells and photovoltaics), organic light-emitting diodes, and organic transistors.
Rules & Requirements

Prerequisites: EL ENG 130; and undergraduate general chemistry

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

Hours & Format

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

Additional Details

Subject/Course Level: Electrical Engineering/Graduate

Grading: Letter grade.

Instructor: Subramanian

EL ENG W290C Advanced Topics in Circuit Design 3 Units

Terms offered: Prior to 2007
Seminar-style course presenting an in-depth perspective on one specific domain of integrated circuit design. Most often, this will address an application space that has become particularly relevant in recent times. Examples are serial links, ultra low-power design, wireless transceiver design, etc.
Rules & Requirements

Prerequisites: MAS-IC students only

Credit Restrictions: Students will receive no credit for W290C after taking 290C.

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

Hours & Format

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

Summer: 10 weeks - 4.5 hours of web-based lecture per week

Online: This is an online course.

Additional Details

Subject/Course Level: Electrical Engineering/Graduate

Grading: Letter grade.

EL ENG C291 Control and Optimization of Distributed Parameters Systems 3 Units

Terms offered: Fall 2017, Spring 2016, Spring 2015, Spring 2014
Distributed systems and PDE models of physical phenomena (propagation of waves, network traffic, water distribution, fluid mechanics, electromagnetism, blood vessels, beams, road pavement, structures, etc.). Fundamental solution methods for PDEs: separation of variables, self-similar solutions, characteristics, numerical methods, spectral methods. Stability analysis. Adjoint-based optimization. Lyapunov stabilization. Differential flatness. Viability control. Hamilton-Jacobi-based control.
Rules & Requirements

Prerequisites: ENGIN 7 and MATH 54; or consent of instructor

Hours & Format

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

Additional Details

Subject/Course Level: Electrical Engineering/Graduate

Grading: Letter grade.

Also listed as: CIV ENG C291F/MEC ENG C236

EL ENG C291E Hybrid Systems and Intelligent Control 3 Units

Terms offered: Spring 2021, Spring 2020, Spring 2018
Analysis of hybrid systems formed by the interaction of continuous time dynamics and discrete-event controllers. Discrete-event systems models and language descriptions. Finite-state machines and automata. Model verification and control of hybrid systems. Signal-to-symbol conversion and logic controllers. Adaptive, neural, and fuzzy-control systems. Applications to robotics and Intelligent Vehicle and Highway Systems (IVHS).

Hours & Format

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

Additional Details

Subject/Course Level: Electrical Engineering/Graduate

Grading: Letter grade.

Formerly known as: 291E

Also listed as: MEC ENG C290S

EL ENG 297 Field Studies in Electrical Engineering 0 - 12 Units

Terms offered: Summer 2024 8 Week Session, Fall 2023, Summer 2023 8 Week Session
Supervised experience in off-campus companies relevant to specific aspects and applications of electrical engineering. Written report required at the end of the semester.

Rules & Requirements

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

Hours & Format

Fall and/or spring: 15 weeks - 1-12 hours of independent study per week

Summer: 8 weeks - 1-12 hours of independent study per week

Additional Details

Subject/Course Level: Electrical Engineering/Graduate

Grading: Offered for satisfactory/unsatisfactory grade only.

EL ENG 298 Group Studies, Seminars, or Group Research 1 - 4 Units

Terms offered: Spring 2023, Spring 2022, Spring 2021
Advanced study in various subjects through special seminars on topics to be selected each year, informal group studies of special problems, group participation in comprehensive design problems, or group research on complete problems for analysis and experimentation.

Rules & Requirements

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

Hours & Format

Fall and/or spring: 15 weeks - 0 hours of lecture per week

Additional Details

Subject/Course Level: Electrical Engineering/Graduate

Grading: The grading option will be decided by the instructor when the class is offered.

EL ENG 299 Individual Research 1 - 12 Units

Terms offered: Fall 2024, Summer 2024 10 Week Session, Summer 2023 10 Week Session
Investigation of problems in electrical engineering.

Rules & Requirements

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

Hours & Format

Fall and/or spring: 15 weeks - 1-12 hours of independent study per week

Summer:
6 weeks - 2.5-30 hours of independent study per week
8 weeks - 1.5-22.5 hours of independent study per week

Additional Details

Subject/Course Level: Electrical Engineering/Graduate

Grading: Offered for satisfactory/unsatisfactory grade only.

EL ENG 375 Teaching Techniques for Electrical Engineering 2 Units

Terms offered: Fall 2025, Spring 2025, Fall 2024
Discussion of effective teaching techniques. Use of educational objectives, alternative forms of instruction, and proven techniques to enhance student learning. This course is intended to orient new student instructors to more effectively teach courses offered by the Department of Electrical Engineering and Computer Sciences at UC Berkeley.

Rules & Requirements

Prerequisites: Teaching assistant or graduate student

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

Hours & Format

Fall and/or spring: 15 weeks - 1.5 hours of seminar per week

Additional Details

Subject/Course Level: Electrical Engineering/Professional course for teachers or prospective teachers

Grading: Offered for satisfactory/unsatisfactory grade only.

EL ENG 602 Individual Study for Doctoral Students 1 - 8 Units

Terms offered: Fall 2016, Fall 2015, Fall 2014
Individual study in consultation with the major field adviser, intended to provide an opportunity for qualified students to prepare themselves for the various examinations required of candidates for the Ph.D. (and other doctoral degrees).

Rules & Requirements

Credit Restrictions: Course does not satisfy unit or residence requirements for doctoral degree.

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

Hours & Format

Fall and/or spring: 15 weeks - 0 hours of independent study per week

Summer: 8 weeks - 6-45 hours of independent study per week

Additional Details

Subject/Course Level: Electrical Engineering/Graduate examination preparation

Grading: Offered for satisfactory/unsatisfactory grade only.