Stanford University

Electrical Engineering Department

About Us

The Department of Electrical Engineering (EE) at Stanford innovates by conducting fundamental and applied research to develop physical technologies, hardware and software systems, and information technologies; it educates future academic and industry leaders; and it prepares students for careers in industry, academia, and research labs.

Electrical Engineering has effected societal changes at the heart of the information revolution. Electrical and electronic devices—realized in both hardware and software—are integral to daily life, whether in the home, in health care, in recreation, or in the infrastructure for communication and computation. Electrical engineers use theories and tools from mathematics and physics to develop systems ranging from smart electric grids, wired and wireless communications and networking, embedded systems, integrated electronics, imaging and sensing devices, to Internet-based information technology.

The Electrical Engineering Department offers the following degrees: Bachelor of Science, Master of Science, and Doctor of Philosophy. The department also offers joint degrees in Electrical Engineering and Law (M.S./J.D.) and Electrical Engineering and Business Administration (M.S./M.B.A.). A minor can be obtained for the Bachelor of Science and Doctor of Philosophy.

Research Areas in Electrical Engineering

Research in Electrical Engineering spans a diverse set of intellectual disciplines and applications. The research areas are listed below:

- AI, Machine Learning, and Optimization
- Biomedical Devices, Sensors, and Systems
- Computational Imaging and Display
- Computer Architecture, Security, and Hardware/Software Systems
- Energy, Environment, and Sustainability
- Information and Coding Theory, Communications, and Signal Processing
- Integrated Circuits and Systems
- Nanotechnology, Nanofabrication, Materials, Advance Packaging, and Manufacturing Technologies
- Quantum Science and Engineering and Photonics
- Robotics and Control

Interdisciplinary Research

EE faculty collaborate with researchers from other departments and schools across campus. More than a quarter of our faculty are joint with other departments, and a similar fraction of our PhD students have advisors outside EE. While the main applications of electrical engineering in the past four decades have been in information technology, EE tools and techniques are being increasingly applied more broadly to address major societal problems in areas such as:

Biomedical

Research in the biomedical area utilizes engineering approaches to address the unmet needs in diagnosis, staging, treatment, and mitigation of illnesses including cancer, diabetes, heart diseases, as well as brain disorders. Lower-cost, prevention-oriented health care delivery is critically needed, as well as new approaches to previously untreatable health conditions. Addressing these challenges requires discovering and creating fundamentally new approaches and creating new devices and systems for critical diagnostics (sensors, imaging), therapeutics (lasers, pacemakers, and neural interfaces), and analytical (high-throughput sequencing, healthcare IT) technologies.

Energy

Research in energy is motivated at the macro level by the rapid rise in worldwide demand for electricity and the threat of global climate change, and on the micro level by the explosion in the number of mobile devices and sensors whose performance and lifetimes are limited by energy.

On the macro level, electronic loads, such as data centers, smart appliances, and electric vehicles, are poised to overtake traditional industrial loads in consumption share. Renewable energy will make up at least half of the generation mix and drive adoption of novel technologies such as storage, fuel cells, waste-to-power and distributed generation. Our research investigates techniques such as demand response and the use of energy storage to reduce peak demand and address variability of renewable energy.

On the micro level, we are exploring energy efficient devices, power electronics, system architectures, and network protocols, as well as ways to harvest energy from the environment for wearable devices and the Internet of things.

For additional information, see the Department of Electrical Engineering's Research website.

People

Browse the people that work for Stanford's Department of Electrical Engineering.

- Our Faculty
- Staff
- Adjunct Faculty
- Postdoctoral Scholars
- Visitors

- Administration

Connect with Us

Use these channels to learn more about our department and reach out to us.

- Visit our website: http://ee.stanford.edu
- Email us: info@ee.stanford.edu
- Call our main office: (650) 723-3931

Find Us on Campus or Send Us Mail

Department of Electrical Engineering
David Packard Electrical Engineering Building
350 Jane Stanford Way
Mail Code: 9505
Stanford, CA 94305

Programs

EE-BS - Electrical Engineering (BS)

Overview

Program Overview

The mission of the undergraduate program of the Department of Electrical Engineering is to augment the liberal education expected of all Stanford undergraduates, to impart a basic understanding of electrical engineering, and to develop skills in the design and building of systems that directly impact societal needs.

The program includes a balanced foundation in the physical sciences, mathematics, and computing; core courses in electronics, information systems, and digital systems; and develops specific skills in the analysis and design of systems. Students in the major have broad flexibility to select from disciplinary areas beyond the core, including hardware and software, information systems and science, physical technology and science, and electives in multidisciplinary areas, including bio-electronics and bio-imaging, energy and environment, and music.

The program prepares students for a broad range of careers—both industrial and government—as well as for professional and academic graduate education.

Preparing for the Major

- Find the steps to declare the EE Major here: https://ee.stanford.edu/academics/undergrad-degree-progress
- Find EE four-year plans and course flow charts here: https://ughb.stanford.edu/majors-minors/electrical-engineering-program

Director of Graduate Studies	Undergraduate/Graduate
John Pauly	Undergraduate

Simple Requisites

Core Program Requirements
Type
Completion Requirement

Requirement Overview

Minimum 40 units Math and Science combined, plus three units of TIS, for a total of 43 units.

It is a School of Engineering requirement that all courses counting toward the major must be taken for a letter grade if the instructor offers that option. Students with multiple degrees should be aware that math, science, and fundamentals courses can be used to fulfill breadth requirements for more than one degree program, but a depth course can be counted toward only one major or minor program; any course can be double counted in a secondary major.

EE-MIN - Electrical Engineering (Minor)

Overview

Program Overview

The EE-MIN degree program consists of 23-25 units minimum of EE coursework as outlined below. Any prerequisite math or science courses outside the EE core and elective courses listed may be duplicated in the major or another degree program.

Director of Graduate Studies	Undergraduate/Graduate
John Pauly	Undergraduate

Simple Requisites

Program Requirements (23-25 units)
Type
Completion Requirement

EE Fundamental (5 units minimum)

Select one EE Fundamental (five units minimum)

Complete ANY of the following Courses:

- EE42 - Introduction to Electromagnetics and Its Applications
- EE65 - Modern Physics for Engineers
- ENGR40M - An Intro to Making: What is EE
- ENGR76 - Information Science and Engineering

Course must be taken for a letter grade if that option is offered.

Select one two-course sequence (eight units minimum).

Complete ANY of the following Courses:

- EE101A - Circuits I
  AND EE101B - Circuits II
- EE102A - Signals and Systems I
  AND EE102B - Signals and Systems II
- EE102A - Signals and Systems I
  AND ENGR108 - Introduction to Matrix Methods
- EE108 - Digital System Design
  AND EE180 - Digital Systems Architecture

All courses must be taken for a letter grade if that option is offered.

Addititional letter-graded courses (12 units minimum)

In addition, four letter-graded EE courses at the 100-level or higher must be taken (12 units minimum). CS107E or CS107 COMP ORG & SYSTEMS is required as a prerequisite for EE180 DIGITAL SYSTEMS ARCHITECTURE but can count as one of the four classes.

You are required to submit a completed program sheet to the EE Department the quarter prior to conferring your EE BS degree.

Mathematics: Select one sequence

Complete ALL of the following Courses:

- MATH19 - Calculus
  AND MATH20 - Calculus
  AND MATH21 - Calculus

This requirement may also be satisfied with AP Calculus.

MATH 41 and MATH 42 are no longer offered and have been replaced by MATH19 CALCULUS, MATH20 CALCULUS, and MATH21 CALCULUS.

Mathematics: Select one two-course sequence. CME 100 and CME 102 can be substituted for MATH 51 and MATH 53. MATH 52 can be substituted for MATH 51. MATH 51 and MATH 53 are recommended, in part, for providing substantial early exposure to linear algebra.

Complete ANY of the following Courses:

- MATH51 - Linear Algebra, Multivariable Calculus, and Modern Applications
  AND MATH53 - Differential Equations with Linear Algebra, Fourier Methods, and Modern Applications
- CME100 - Vector Calculus for Engineers
  AND CME102 - Ordinary Differential Equations for Engineers

CME100 VECTOR CALCULUS FOR ENGINEERS is same as ENGR154 VECTOR CALCULUS FOR ENGINEERS. CME102 ODE FOR ENGINEERS is same as ENGR155A ODE FOR ENGINEERS.

MATH51 LIN ALG, MULTIVAR CALC,MOD APP may be replaced by MATH52 MULTIVAR INTEGRAL CALCULUS. MATH53 DIFF'TL EQNS & FOURIER METHODS may be replaced by CME102 ODE FOR ENGINEERS.

Mathematics: EE Math. One additional 100-level course. Select one.

Complete ANY of the following Courses:

- CS103 - Mathematical Foundations of Computing
- ENGR108 - Introduction to Matrix Methods
- MATH113 - Linear Algebra and Matrix Theory

If used for math, ENGR108 INTRODUCTION TO MATRIX METHODS may not be used as an EE disciplinary elective.

Mathematics: Statistics/Probability

Complete ALL of the following Courses:

- EE178 - Probabilistic Systems Analysis

Students may petition to use CS109 INTRO TO PROB FOR COMP SCIENT in place of EE178 INTR PROBABLISTIC SYS ANALYSIS. Students are strongly encouraged to take EE178 INTR PROBABLISTIC SYS ANALYSIS to learn key EE topics, especially those specializing in the Info Systems and Science disciplinary area.

Science (3 courses, minimum 12 units)

Fulfill ALL of the following requirements:

Complete ANY of the following Courses:

- PHYSICS41 - Mechanics
  AND EE65 - Modern Physics for Engineers
- PHYSICS61 - Mechanics and Special Relativity
  AND EE65 - Modern Physics for Engineers

but can count as one of the four classes.

Earn at least 12 credits

All courses taken for the minor must be taken for a letter grade if that option is offered by the instructor.

Additional Comments:

Students may petition to have either PHYSICS71 QUANTUM & THERMAL PHYSICS or the combination of PHYSICS45 LIGHT AND HEAT and PHYSICS70 FOUNDATIONS OF MODERN PHYSICS (last offered Aut 2022) count as an alternative to EE65 MODERN PHYSICS FOR ENGINEERS.

AND

Science Elective

Complete at least one of the following courses:

Complete at least 1 of the following courses:

- BIO30 - Ecology for Everyone
- BIO81 - Introduction to Ecology
- BIO82 - Genetics
- BIO83 - Biochemistry & Molecular Biology
- BIO84 - Physiology
- BIO85 - Evolution
- BIO86 - Cell Biology
- BIO45 - Introduction to Laboratory Research in Cell and Molecular Biology
- BIO46 - Introduction to Research in Ecology and Evolutionary Biology
- BIO47 - Introduction to Research in Ecology and Evolutionary Biology
- BIO150 - Human Behavioral Biology
- CEE63 - Weather and Storms
- CEE64 - Air Pollution and Global Warming: History, Science, and Solutions
- CEE70 - Environmental Science and Technology
- CHEM31A - Chemical Principles I
- CHEM31B - Chemical Principles II
- CHEM33 - Structure and Reactivity of Carbon-Based Molecules
- CHEM121 - Understanding the Natural and Unnatural World through Chemistry
- CHEM123 - Organic Polyfunctional Compounds
- EARTHSYS2 - Chemistry of the Earth and Planets
- EARTHSYS10 - Introduction to Earth Systems
- EARTHSYS11 - Introduction to Geology
- PHYSICS41 - Mechanics
- PHYSICS41E - Mechanics, Concepts, Calculations, and Context
- PHYSICS42 - Classical Mechanics Laboratory
- PHYSICS43 - Electricity and Magnetism
- PHYSICS44 - Electricity and Magnetism Lab
- PHYSICS45 - Light and Heat
- PHYSICS46 - Light and Heat Laboratory
- PHYSICS61 - Mechanics and Special Relativity
- PHYSICS61L - Mechanics Laboratory
- PHYSICS71 - Quantum and Thermal Physics
- PHYSICS71L - Modern Physics Laboratory
- PHYSICS81 - Electricity and Magnetism Using Special Relativity and Vector Calculus
- PHYSICS89L - Introduction to Data Analysis, with Python and Jupyter

Please visit HERE for more notes about Science courses.

TECHNOLOGY IN SOCIETY

Complete ANY of the following Courses:

- AA252 - Techniques of Failure Analysis
- ANTHRO132C - Technology and Inequality
- ARCHLGY151 - Ten Things: An Archaeology of Design
- BIOE131 - Ethics in Bioengineering
- BIOE177 - Inventing the Future
- CEE102A - Legal / Ethical Principles in Design, Construction, Project Delivery
- CEE145E - Equitable Infrastructure Solutions
- CLASSICS168 - Engineering the Roman Empire
- COMM120W - The Rise of Digital Culture
- COMM166 - Virtual People
- CS125 - Data: Algorithms, Tools, Policy, and Society
- CS152 - Trust and Safety
- CS181 - Computers, Ethics, and Public Policy
- CS182 - Ethics, Public Policy, and Technological Change
- CS256 - Algorithmic Fairness
- CS278 - Social Computing
- DATASCI154 - Solving Social Problems with Data
- EARTHSYS125 - Shades of Green: Exploring and Expanding Environmental Justice in Practice
- ENGR117 - Expanding Engineering Limits: Culture, Diversity, and Equity
- ENGR145 - Technology Entrepreneurship
- ENGR148 - Principled Entrepreneurial Decisions
- ENGR248 - Principled Entrepreneurial Decisions
- HUMBIO174 - Foundations of Bioethics
- MS&E193 - Technology and National Security
- ME267 - Ethics and Equity in Transportation Systems (Inactive)
- POLISCI114S - International Security in a Changing World
- PUBLPOL114 - Spies, Lies, and Algorithms: The History and Future of American Intelligence
- PUBLPOL134 - Ethics on the Edge: Business, Non-Profit Organizations, Government, and Individuals
- STS1 - Introduction to Science, Technology & Society
- STS200J - Technometabolism: Technology, Society, and the Anthropocene

One course, see Basic Requirement 4 in the School of Engineering section. The course taken must be on the School of Engineering Approved Courses list the year it is taken. Please visit HERE for more notes about TiS courses.

ENGINEERING TOPICS

Minimum 57 units comprised of Engineering Fundamentals (minimum eight units), Core Electrical Engineering Courses (minimum 18 units), Disciplinary Area (minimum 15 units), and Electives (maximum 16 units, restrictions apply).

Engineering Fundamentals (2 courses required; minimum 8 units)

Fulfill ALL of the following requirements:

Engineering Fundamentals Required Course

Complete ALL of the following Courses:

- CS106B - Programming Abstractions

Students may take CS 106B OR CS 106B + CS 106M to fulfill the requirement.

AND

Engineering Fundamentals Elective Course

Choose one Fundamental course from the list below.

Complete at least 1 of the following courses:

- ENGR10 - Introduction to Engineering Analysis
- ENGR14 - Intro to Solid Mechanics
- ENGR15 - Dynamics
- ENGR20 - Introduction to Chemical Engineering
- ENGR21 - Engineering of Systems
- ENGR40M - An Intro to Making: What is EE
- ENGR42 - Introduction to Electromagnetics and Its Applications
- ENGR50 - Introduction to Materials Science, Nanotechnology Emphasis
- ENGR50E - Introduction to Materials Science, Energy Emphasis
- ENGR50M - Introduction to Materials Science, Biomaterials Emphasis
- ENGR55 - Foundational Biology for Engineers
- ENGR60 - Engineering Economics and Sustainability
- ENGR62 - Introduction to Optimization
- ENGR62X - Introduction to Optimization (Accelerated)
- ENGR65 - Modern Physics for Engineers
- ENGR76 - Information Science and Engineering
- ENGR80 - Introduction to Bioengineering (Engineering Living Matter)
- ENGR90 - Environmental Science and Technology

Recommended: ENGR40M AN INTRO TO MAKING: WHAT IS EE (recommended before taking EE101A CIRCUITS 1) or ENGR76 INFORMATION SCIENCE AND ENG (recommended before taking EE102A SIGNAL SYS I). A second ENGR 40-series course is not allowed for the Fundamentals elective.

Core Electrical Engineering Courses (Minimum 18 units)

Complete ALL of the following Courses:

- EE42 - Introduction to Electromagnetics and Its Applications
- EE100 - The Electrical Engineering Profession
- EE101A - Circuits I
- EE102A - Signals and Systems I
- EE108 - Digital System Design

Students preparing for advanced graduate study or wanting additional depth in the core are encouraged to take some of the disciplinary area requirements (EE101B, EE102B, CS107E, or CS107, EE180) beyond those required for their chosen disciplinary area. These may be counted toward Electives.

Many students take PHYSICS43 ELECTRICITY & MAGNETISM or PHYSICS81 ELECTRICITY AND MAGNETISM (formerly Physics 63) before declaring the EE major. Students (except those specializing in Physical Technology and Science) may petition to use either PHYSICS43 ELECTRICITY & MAGNETISM or PHYSICS81 ELECTRICITY AND MAGNETISM instead of EE42 INTRO ENGINEERING ELECTROMAGNE. Nevertheless, students are strongly encouraged to take EE42 INTRO ENGINEERING ELECTROMAGNE or EE142 ENGINEERING ELECTROMAGNETICS to learn key EE topics, including transmission lines, waveguides, and antennas. Students specializing in Physical Technology and Science must take EE42 INTRO ENGINEERING ELECTROMAGNE or EE142 ENGINEERING ELECTROMAGNETICS.

For upper-division students, a 200-level seminar in their disciplinary area will be accepted on petition.

Electives

The elective units should be sufficient to meet the 57-unit total for the major, over and above the 43 units of Math and Science. Depending on units completed in the Disciplinary Area (see Depth in Discipline section), elective units will be in the range of 16 units or less. Students may select electives from the disciplinary areas, the multidisciplinary elective areas, or any combination of disciplinary and multidisciplinary areas. Electives may include up to two additional Engineering Fundamentals and any letter-graded EE courses (minus any previously noted restrictions). Frosh and Sophomore seminars, EE191 SPECIAL STUDIES/REPORTS IN EE does not count toward the 57 units. Students may have fewer elective units if they have more units in their disciplinary area.

A course may only be counted toward one requirement, not double-counted. All courses taken for the major must be taken for a letter grade if the instructor offers that option. The Minimum Combined GPA for all courses in Engineering Fundamentals and Depth is 2.0.

Additional Comments:

Depth in Discipline
Type
Completion Requirement

Hardware and Software

Complete ALL of the following Courses:

- EE180 - Digital Systems Architecture
- CS107E - Computer Systems from the Ground Up
  OR CS107 - Computer Organization and Systems

Design Courses

Complete at least 1 of the following courses:

- EE109 - Digital Systems Design Lab
- EE184 - Internet Principles and Protocols
- EE264 - Digital Signal Processing
- EE264W - Digital Signal Processing (WIM)
- EE267 - Virtual Reality
- EE267W - Virtual Reality (WIM)
- CS194W - Software Project (WIM)

Students may select their Design course from any Disciplinary Area.

To satisfy Design, EE264 DIGITAL SIGNAL PROCESSING or EE267 VIRTUAL REALITY must be taken for four units, and the laboratory project must be completed.

Electives

Complete at least 1 of the following courses:

- EE104 - Introduction to Machine Learning
- EE107 - Embedded Networked Systems (Inactive)
- EE118 - Introduction to Mechatronics
- EE156 - Board Level Design
- EE192T - Project Lab: Video and Audio Technology for Live Theater in the Age of COVID (Inactive)
- EE271 - Introduction to VLSI Systems
- EE272 - Design Projects in VLSI Systems I
- EE273 - Digital Systems Engineering
- EE277 - Bandit Learning: Behaviors and Applications
- EE282 - Computer Systems Architecture

- EE285 - Embedded Systems Workshop
- EE292S - Understanding the Sensors in your Smartphone
- EE372 - Design Projects in VLSI Systems II
- CS108 - Object-Oriented Systems Design
- CS111 - Operating Systems Principles
- CS112 - Operating systems kernel implementation project
- CS131 - Computer Vision: Foundations and Applications
- CS140 - Operating Systems and Systems Programming
- CS143 - Compilers
- CS144 - Introduction to Computer Networking
- CS145 - Introduction to Big Data Systems
- CS148 - Introduction to Computer Graphics and Imaging
- CS149 - Parallel Computing
- CS155 - Computer and Network Security
- CS161 - Design and Analysis of Algorithms
- CS221 - Artificial Intelligence: Principles and Techniques
- CS223A - Introduction to Robotics
- CS224N - Natural Language Processing with Deep Learning
- CS225A - Experimental Robotics
- CS229 - Machine Learning
- CS231A - Computer Vision: From 3D Perception to 3D Reconstruction and Beyond
- CS231N - Deep Learning for Computer Vision
- CS241 - Embedded Systems Workshop
- CS244 - Advanced Topics in Networking

Information Systems and Science

Complete ALL of the following Courses:

- EE102B - Signals and Systems II

Design Courses

Complete at least 1 of the following courses:

- EE133 - Analog Communications Design Laboratory
- EE168 - Introduction to Digital Image Processing
- EE262 - Three-Dimensional Imaging (Inactive)
- EE264 - Digital Signal Processing
- EE264W - Digital Signal Processing (WIM)
- EE267 - Virtual Reality
- EE267W - Virtual Reality (WIM)

Students may select their Design course from any Disciplinary Area.

To satisfy Design, EE264 DIGITAL SIGNAL PROCESSING or EE267 VIRTUAL REALITY must be taken for four units, and the laboratory project must be completed.

Electives

Complete at least 2 of the following courses:

- EE104 - Introduction to Machine Learning
- EE107 - Embedded Networked Systems (Inactive)
- EE118 - Introduction to Mechatronics
- EE124 - Introduction to Neuroelectrical Engineering
- EE169 - Introduction to Bioimaging
- EE179 - Analog and Digital Communication Systems
- EE192T - Project Lab: Video and Audio Technology for

Live Theater in the Age of COVID (Inactive)

- EE259 - Principles of Sensing for Autonomy
- EE260A - Principles of Robot Autonomy I
- EE260B - Principles of Robot Autonomy II
- EE261 - The Fourier Transform and Its Applications
- EE263 - Introduction to Linear Dynamical Systems
- EE266 - Introduction to Stochastic Control with Applications (Inactive)
- EE269 - Signal Processing for Machine Learning
- EE274 - Data Compression: Theory and Applications
- EE276 - Information Theory
- EE277 - Bandit Learning: Behaviors and Applications
- EE278 - Probability and Statistical Inference
- EE279 - Introduction to Digital Communication
- ENGR105 - Feedback Control Design
- ENGR205 - Introduction to Control Design Techniques
- CS107 - Computer Organization and Systems
- CS107E - Computer Systems from the Ground Up
- CS229 - Machine Learning

Physical Technology and Science

Complete ALL of the following Courses:

- EE101B - Circuits II

Design Courses

Complete at least 1 of the following courses:

- EE133 - Analog Communications Design Laboratory
- EE134 - Introduction to Photonics
- EE153 - Power Electronics
- EE267 - Virtual Reality
- EE267W - Virtual Reality (WIM)

Students may select their Design course from any Disciplinary Area.

To satisfy Design, EE267 VIRTUAL REALITY must be taken for four units, and the laboratory project must be completed.

Electives

Complete at least 2 of the following courses:

- EE107 - Embedded Networked Systems (Inactive)
- EE114 - Fundamentals of Analog Integrated Circuit Design
- EE116 - Semiconductor Devices for Energy and Electronics
- EE118 - Introduction to Mechatronics
- EE124 - Introduction to Neuroelectrical Engineering
- EE142 - Engineering Electromagnetics
- EE156 - Board Level Design
- EE157 - Electric Motors for Renewable Energy, Robotics, and Electric Vehicles
- EE212 - Integrated Circuit Fabrication Processes
- EE214B - Advanced Integrated Circuit Design
- EE216 - Principles and Models of Semiconductor Devices
- EE222 - Applied Quantum Mechanics I
- EE223 - Applied Quantum Mechanics II
- EE228 - Basic Physics for Solid State Electronics
- EE236A - Modern Optics
- EE236B - Guided Waves
- EE242 - Electromagnetic Waves
- EE247 - Introduction to Optical Fiber Communications
- EE259 - Principles of Sensing for Autonomy

- EE259 - Principles of Sensing for Autonomy
- EE271 - Introduction to VLSI Systems
- EE272 - Design Projects in VLSI Systems I
- EE273 - Digital Systems Engineering
- EE282 - Computer Systems Architecture
- EE372 - Design Projects in VLSI Systems II
- ENGR105 - Feedback Control Design
- ENGR205 - Introduction to Control Design Techniques
- CS107 - Computer Organization and Systems
- CS107E - Computer Systems from the Ground Up

Multidisciplinary Electives Area

Students may select electives from the disciplinary areas, the multidisciplinary elective areas, or any combination of disciplinary and multidisciplinary areas. Electives may include up to two additional Engineering Fundamentals and any letter-graded EE courses. Frosh and Sophomore seminars, EE191 SPECIAL STUDIES/REPORTS IN EE does not count toward the 57 units. Students may have fewer elective units if they have more units in their disciplinary area.

Multidisciplinary elective areas include Bio-Electronics and Bio-Imaging, Energy and Environment, and Music. Courses in multidisciplinary elective areas are listed below.

Bio-Electronics and Bio-Imaging

Complete ANY of the following Courses:

- EE101B - Circuits II
- EE102B - Signals and Systems II
- EE107 - Embedded Networked Systems (Inactive)
- EE124 - Introduction to Neuroelectrical Engineering
- EE134 - Introduction to Photonics
- EE168 - Introduction to Digital Image Processing
- EE169 - Introduction to Bioimaging
- EE225 - Biochips and Medical Imaging
- EE235A - Analytical Methods in Biotechnology I
- EE235B - Analytical Methods in Biotechnology II (Inactive)
- EE267 - Virtual Reality
- EE267W - Virtual Reality (WIM)
- BIOE131 - Ethics in Bioengineering
- BIOE248 - Neuroengineering Laboratory (Inactive)
- MED275B - Biodesign Fundamentals (Inactive)
- RAD206 - Mixed-Reality in Medicine
- RAD220 - Introduction to Imaging and Image-based Human Anatomy

Energy and Environment

Complete ANY of the following Courses:

- EE101B - Circuits II
- EE116 - Semiconductor Devices for Energy and Electronics
- EE134 - Introduction to Photonics
- EE151 - Sustainable Energy Systems (Inactive)
- EE153 - Power Electronics
- EE157 - Electric Motors for Renewable Energy, Robotics, and Electric Vehicles
- EE168 - Introduction to Digital Image Processing
- EE180 - Digital Systems Architecture
- EE263 - Introduction to Linear Dynamical Systems
- EE293B - Fundamentals of Energy Processes
  OR ENERGY201B - Fundamentals of Energy Processes

- ENGR105 - Feedback Control Design
- ENGR205 - Introduction to Control Design Techniques
- CEE107A - Understand Energy
- CEE155 - Introduction to Sensing Networks for CEE
- CEE176A - Energy Efficient Buildings
- CEE176B - 100% Clean, Renewable Energy and Storage for Everything
- ENERGY201C - Energy storage and conversion systems: Solar Cells, Fuel Cells, Batteries
- MATSCI142 - Quantum Mechanics of Nanoscale Materials
- MATSCI152 - Electronic Materials Engineering
- MATSCI156 - Solar Cells, Fuel Cells, and Batteries: Materials for the Energy Solution
- MATSCI164 - Electronic and Photonic Materials and Devices Laboratory

Music

Complete ANY of the following Courses:

- EE102B - Signals and Systems II
- EE109 - Digital Systems Design Lab
- MUSIC250A - Physical Interaction Design for Music
- MUSIC253 - Symbolic Musical Information
- MUSIC254 - Computational Music Analysis
- EE264 - Digital Signal Processing
- EE264W - Digital Signal Processing (WIM)
- MUSIC256A - Music, Computing, Design: The Art of Design
- MUSIC257 - Neuroplasticity and Musical Gaming
- MUSIC356 - Music and AI
- MUSIC422 - Perceptual Audio Coding
- MUSIC424 - Signal Processing Techniques for Digital Audio Effects

MUSIC420A SIGNAL PROCESSING MODELS, MUSIC422 PERCEPTUAL AUDIO CODING, and MUSIC424 SIGNAL PROCESSING are best taken as a coterm student.

Additional Comments:
Disciplinary Area Courses: Minimum 17 Units

Writing in the Major (WIM)
Type
Completion Requirement

Select one. A single course can concurrently meet the Capstone, WIM and Design Requirements.

Complete ANY of the following Courses:

- EE109 - Digital Systems Design Lab
- EE133 - Analog Communications Design Laboratory
- EE134 - Introduction to Photonics
- EE153 - Power Electronics
- EE155 - Green Electronics (Inactive)
- EE168 - Introduction to Digital Image Processing
- EE191W - Special Studies and Reports in Electrical Engineering (WIM)
- EE264W - Digital Signal Processing (WIM)
- EE267W - Virtual Reality (WIM)
- CS194W - Software Project (WIM)

EE191W SPECIAL STUDIES & REPORTS WIM may satisfy WIM only if it is a follow-up to an REU or independent study project or as part of an honors thesis project and a faculty member agrees to supervise the writing of a technical paper, with proper support from the Writing Center.

Additional Comments:

Capstone Experience
Type
Completion Requirement

Capstone/WIM Requirement

See the Writing in the Major section above for information on the joint Writing in the Major/Capstone requirement.

Additional Comments:

Honors (Optional)
Type
Completion Requirement

Additional Comments:
The Department of Electrical Engineering offers a program leading to a Bachelor of Science in Electrical Engineering with Honors. This program provides a unique opportunity for qualified undergraduate majors to conduct independent study and research at an advanced level with a faculty mentor, graduate students, and fellow undergraduates.

Admission to the honors program is by application. Declared EE majors with a grade point average (GPA) of at least 3.5 in Electrical Engineering are eligible to apply. Applications must be submitted by autumn quarter of the senior year, be signed by the thesis advisor and second reader (one must be a member of the EE Faculty), and include an honors proposal. Students need to declare the EE Honors major on Axess.

To receive departmental honors, students admitted to the honors program must:

1. Submit an Undergraduate Honors Program Application, including the thesis proposal, to the Degree Progress Officer via email by autumn quarter of the senior year, signed by the thesis advisor and second reader (one must be an Electrical Engineering faculty member).
2. Declare the EE Honors major in Axess before the end of autumn quarter of the senior year.
3. Maintain a grade point average of at least 3.5 in Electrical Engineering courses.
4. Complete at least ten units of EE191 SPECIAL STUDIES/REPORTS IN EE or EE191W SPECIAL STUDIES & REPORTS WIM with the thesis advisor for a letter grade. EE191 SPECIAL STUDIES/REPORTS IN EE units do not count toward the required 60 units, except EE191W SPECIAL STUDIES & REPORTS WIM, which is approved to satisfy WIM. A minimum grade of B+ is required for EE191 SPECIAL STUDIES/REPORTS IN EE or EE191W SPECIAL STUDIES & REPORTS WIM to receive honors.
5. Submit one final copy of the honors thesis approved by the advisor and second reader to the Degree Progress Officer by May 15th.
6. Attend poster and oral presentation at the end of spring quarter or present in another appropriate forum approved by the faculty advisor.

The EE department is participating in the Bing Honors College (BHC). If you want to participate in this program, confirm your participation with EE and sign up for BHC.

Program Policies

External Credit Policies

Transfer and AP credits in Math, Science, Fundamentals, and the Technology in Society course must be confirmed for the major by the School of Engineering Dean's office. See the UGHB page on petitions for more information.

Learning Outcomes

Program Learning Outcomes

The department expects undergraduate majors in the program to be able to demonstrate the following learning outcomes. These learning outcomes are used in evaluating students and the department's undergraduate program. The educational objectives of the program are:

- Technical knowledge: Provide an understanding of electrical engineering principles and the required supporting knowledge of computing, engineering fundamentals, mathematics, and science. The program must include depth in at least one disciplinary area, including hardware and software, information systems and science, physical technology and science, bio-electronics and bio-imaging, energy and environment, or music (signal processing and transducers).
- Laboratory and design skills: Develop the essential skills to perform and design experimental projects. Develop the ability to formulate problems and projects and to plan a process for preparing solutions, taking advantage of diverse technical knowledge and skills.
- Communications skills: Develop the ability to organize and present information and to write and speak effective English.
- Preparation for further study: Provide sufficient breadth and depth for successful subsequent graduate study, postgraduate study, or lifelong learning programs.
- Preparation for the profession: Provide an appreciation for the broad spectrum of issues arising in professional practice, including economics, ethics, leadership, professional organizations, safety, service, and teamwork.

EE-MS - Electrical Engineering (MS)

Overview

Program Overview

Students with undergraduate degrees in electrical engineering, other branches of engineering, physics, mathematics, or related sciences are invited to apply for admission. Capable students without such undergraduate preparation may also be considered for admission. Students may hold either a BS or BA degree. Graduate study in electrical engineering requires that students be adequately prepared in circuits, digital systems, fields, lab work, mathematics, and physics. Students should typically be able to complete the master's degree in five quarters; note that most courses are not offered during the Summer.

In planning a course of study, it is the student's responsibility, in consultation with an advisor, to determine whether the prerequisites for advanced courses have been met. Prerequisite courses ordinarily taken by undergraduates may be included as part of the graduate program of study. However, if the number of these is large, the proposed program may contain more than the minimum 45 units, and the time required to meet the degree requirements may be increased.

The master's degree program provides advanced preparation for

EE-PHD - Electrical Engineering (PhD)

Overview

Program Overview

The Electrical Engineering PhD degree is designed to prepare students for careers in research and teaching at the university level.

The PhD in Electrical Engineering is a specialized degree built on a broad science, mathematics, and engineering skills base. The course program must reflect competency in Electrical Engineering and specialized study in other areas relevant to the student's research focus. Students should discuss their course selection with their dissertation advisor.

The University's basic requirements for the PhD degree are outlined in the Graduate Degrees. Department requirements are stated below.

Students in the PhD program must complete the following requirements: (1) a qualifying examination given by the faculty of the Department of Electrical Engineering; (2) an approved program of study in Electrical Engineering and allied subjects; (3) an approved topic of research and a written dissertation, based on research, which must be a significant contribution to knowledge; (4) and an oral examination that is a defense of dissertation research and is taken near the completion of the doctoral program.

professional practice or junior college-level teaching. Faculty are assigned as program advisors to guide course selection and exploration of academic opportunities and professional pathways. Each student, with the help of a program advisor, prepares an individual program and submits it to the Department for approval. The program proposal must be submitted to the Degree Progress Officer before the end of the first quarter of graduate study (second quarter for Honors Cooperative Program students); a final revised version is due at the beginning of the last quarter of study, before degree conferral. Detailed requirements and instructions are in the Electrical Engineering Department Graduate Handbook. All requirements for a master's degree must be completed within three years after the student's first term of enrollment in the master's program (five years for Honors Cooperative Program students).

Admissions Information

Electrical Engineering MS Admissions information can be found here: https://ee.stanford.edu/admissions/ms

Director of Graduate Studies	**Undergraduate/Graduate**
Prof. Brad Osgood	Graduate

Simple Requisites

Program Requirements

Type

Completion Requirement

Depth Requirement

Complete 12 units from only one of the five (5) area lists. All depth courses must be 200-level and above. At least six units must be at the 300-level or above.

Fulfill ALL of the following requirements:

Depth Area 1: Circuits

Complete at least 4 of the following courses:

- EE207 - Neuromorphics: Brains in Silicon
- EE214A - Fundamentals of Analog Integrated Circuit Design
- EE214B - Advanced Integrated Circuit Design
- EE216 - Principles and Models of Semiconductor Devices
- EE233 - Analog Communications Design Laboratory
- EE251 - High-Frequency Circuit Design Laboratory
- EE253 - Power Electronics
- EE254 - Advanced Topics in Power Electronics
- EE255 - Green Electronics (Inactive)
- EE256 - Board Level Design
- EE271 - Introduction to VLSI Systems
- EE272 - Design Projects in VLSI Systems I
- EE273 - Digital Systems Engineering
- EE292S - Understanding the Sensors in your Smartphone
- EE292X - Battery Systems for Transportation and Grid Services (Inactive)
- EE303 - Autonomous Implantable Systems
- EE308 - Advanced Circuit Techniques
- EE309A - Semiconductor Memory Devices and Circuit Design
- EE314A - RF Integrated Circuit Design
- EE315 - Analog-Digital Interface Circuits
- EE356A - Resonant Converters
- EE356B - Magnetics Design in Power Electronics
- EE371 - Advanced VLSI Circuit Design (Inactive)
- EE372 - Design Projects in VLSI Systems II
- EE414 - RF Transceiver Design Laboratory (Inactive)

See the Electrical Engineering Department website for complete requirements and additional information,

Financial Assistance

The Department awards a limited number of fellowships, teaching and course assistantships, and research assistantships to incoming graduate students. Applying for financial assistance is part of the admission application.

Admissions Information

For EE-PhD Admissions information, please visit: https://ee.stanford.edu/admissions/phd.

Director of Graduate Studies	**Undergraduate/Graduate**
Brad Osgood	Graduate

Simple Requisites

Program Requirements

Type

Completion Requirement

Fulfill ALL of the following requirements:

Introductory Research Seminar

1 unit of seminar course EE301 INTRODUCTORY RESEARCH SEMINAR(Introductory Research Seminar in Electrical Engineering).

Complete ALL of the following Courses:

- EE301 - Introductory Research Seminar in Electrical Engineering

Students must take this course in autumn quarter of their first year.

AND

Letter-Graded Coursework

21 units of letter-graded lecture/lab courses at the 200 level or above in STEM fields - engineering, natural sciences, math, or statistics.

AND

Other Units

The remaining units required to complete the 135 total units may be comprised of:

· Special Studies (e.g. EE390 or EE391)

· Research units (e.g. EE400)

· Seminar units

· Additional lecture/lab courses taken CR/NC or for letter grades.

· Non-departmental units in nontechnical areas

Complete ANY of the following Courses:

- EE390 - Special Studies or Projects in Electrical Engineering
- EE391 - Special Studies and Reports in Electrical Engineering
- EE400 - Thesis and Thesis Research

Additional Comments:

Degree Requirements

Students must maintain a minimum cumulative GPA of 3.0 to maintain

AND

Depth Area 2: Software and Hardware Systems

Complete at least 4 of the following courses:

- BIODS220 - Artificial Intelligence in Healthcare (Inactive)
- CS221 - Artificial Intelligence: Principles and Techniques
- CS228 - Probabilistic Graphical Models: Principles and Techniques
- CS229 - Machine Learning
- CS230 - Deep Learning
- CS231A - Computer Vision: From 3D Perception to 3D Reconstruction and Beyond
- CS231N - Deep Learning for Computer Vision
- CS236 - Deep Generative Models
- CS240 - Advanced Topics in Operating Systems
- CS243 - Program Analysis and Optimizations
- CS244 - Advanced Topics in Networking
- CS245 - Principles of Data-Intensive Systems
- CS246 - Mining Massive Data Sets
- CS248A - Computer Graphics: Rendering, Geometry, and Image Manipulation
- CS248B - Fundamentals of Computer Graphics: Animation and Simulation
- CS255 - Introduction to Cryptography
- CS316 - Advanced Multi-Core Systems (Inactive)
- CS341 - Project in Mining Massive Data Sets (Inactive)
- CS347 - Human-Computer Interaction: Foundations and Frontiers
- CS348A - Computer Graphics: Geometric Modeling & Processing
- CS348B - Computer Graphics: Image Synthesis Techniques
- CS348K - Visual Computing Systems
- CS354 - Topics in Intractability: Unfulfilled Algorithmic Fantasies
- CS357S - Formal Methods for Computer Systems
- CS369L - Algorithmic Perspective on Machine Learning (Inactive)
- EE272 - Design Projects in VLSI Systems I
- EE273 - Digital Systems Engineering
- EE282 - Computer Systems Architecture
- EE284 - Introduction to Computer Networks
- EE284A - Introduction to Internet of Things
- EE285 - Embedded Systems Workshop
- EE292D - Machine Learning on Embedded Systems
- EE292S - Understanding the Sensors in your Smartphone
- EE292Y - Software Techniques for Emerging Hardware Platforms
- EE372 - Design Projects in VLSI Systems II
- EE382A - Parallel Processors Beyond Multicore Processing
- EE382C - Interconnection Networks

AND

Depth Area 3: Communications and Networking

good academic standing and graduate with the EE PhD degree. The PhD degree is offered exclusively as a full-time program consisting of 135 units. The candidacy for the PhD program is five years.

Students in the PhD program are required to complete 135 units of unduplicated coursework. Note that up to 45 units of a master's degree earned at Stanford or another institution in Electrical Engineering or other science/engineering/math fields may be counted toward the 135 units required for the doctoral degree. Please see the Graduate Residency Transfer Credit policy.

Students who wish to receive a master's degree in Electrical Engineering from Stanford may count the 21 units of lecture/lab courses mentioned above toward the requirements for that degree (45 total units are required to earn a master's degree). They must submit the Graduate Authorization Petition in Axess to open the degree and then submit the MS Proposal form that lists the courses taken to fulfill that degree. PhD students that wish to open the master's degree must confer the degree within three (3) years of the first master's degree quarter.

Students wishing to earn an MS degree in a different science or engineering department at Stanford instead of EE in partial fulfillment of the 135 units may submit a request to the Degree Progress Officer to be reviewed by the Associate Chair of Graduate Education.

The proposed program of study for the PhD program must be listed on the Application for Candidacy for Ph.D. Degree. An explanation and the approval of the dissertation advisor must accompany any deviations from these guidelines. All deviations must be approved by the Associate Chair of Graduate Education (submit all requests for program deviations to the Degree Progress Officer).

Advancement to Candidacy
Type
Completion Requirement

Advancing to Candidacy

Fulfill ALL of the following requirements:

Qualifying Exams

Students in the PhD program wishing to advance to candidacy must first pass the Electrical Engineering Qualifying Exams before the end of winter quarter of their second year of study: https://ee.stanford.edu/academics/graduate-degree-progress/quals.

AND

Application for Candidacy

The student's Principal Dissertation Advisor and the Second Reader must sign the Application for Candidacy. The dissertation advisor and/or second reader must have a full or joint appointment in the Electrical Engineering department. The form is then submitted by the end of the second year to the EE Degree Progress Officer, who will obtain the Associate Chair of Graduate Education's approval.

Additional Comments:
Admission to a graduate program does not imply that the student is automatically a candidate for the PhD degree. Advancement to candidacy requires superior academic achievement, satisfactory performance on a qualifying examination, and sponsorship by two

Complete at least 4 of the following courses:

- CS244 - Advanced Topics in Networking
- CS344 - Topics in Computer Networks
- CS351 - Open Problems in Coding Theory
- EE247 - Introduction to Optical Fiber Communications
- EE274 - Data Compression: Theory and Applications
- EE276 - Information Theory
- EE279 - Introduction to Digital Communication
- EE284 - Introduction to Computer Networks
- EE284A - Introduction to Internet of Things
- EE348 - Advanced Optical Fiber Communications
- EE358 - Wireless System Design
- EE359 - Wireless Communications
- EE374 - Blockchain Foundations
- EE376B - Topics in Information Theory and Its Applications (Inactive)
- EE376C - Universal Information Processing
- EE376D - Wireless Information Theory (Inactive)
- EE379 - Digital Communication
- EE392AA - Multi-User Data Transmission
- EE382C - Interconnection Networks
- EE384A - Internet Switching and Routing Protocols
- EE384C - Wireless Local and Wide Area Networks (Inactive)
- EE384E - Networked Wireless Systems (Inactive)
- EE384S - Performance Engineering of Computer Systems & Networks
- EE387 - Algebraic Error Correcting Codes
- EE388 - Modern Coding Theory (Inactive)
- MS&E335 - Queueing and Scheduling in Processing Networks

AND

Depth Area 4: Physical Technology and Science

Complete at least 4 of the following courses:

- EE212 - Integrated Circuit Fabrication Processes
- EE216 - Principles and Models of Semiconductor Devices
- EE218 - Power Semiconductor Devices and Technology
- EE219 - 3D+ Imaging Sensors
- EE222 - Applied Quantum Mechanics I
- EE223 - Applied Quantum Mechanics II
- EE224 - Quantum Control and Engineering
- EE225 - Biochips and Medical Imaging
- EE234 - Photonics Laboratory
- EE235A - Analytical Methods in Biotechnology I
- EE235B - Analytical Methods in Biotechnology II (Inactive)
- EE236A - Modern Optics
- EE236B - Guided Waves
- EE236C - Lasers
- EE237 - Solar Energy Conversion
- EE238 - Introduction to Fourier Optics
- EE242 - Electromagnetic Waves
- EE243 - Photonic Devices and Circuits (Inactive)
- EE247 - Introduction to Optical Fiber Communications
- EE252 - Antennas (Inactive)

faculty members: a dissertation advisor and a second reader. Enrollment in EE 391, Special Studies, is recommended to get acquainted with a faculty member who might be the dissertation advisor.

Students admitted to the PhD program must take the department-qualifying examination. Students must pass the qualifying exam before the end of winter quarter of their second year of study. Students who have never taken the qualifying examination or have not passed the qualifying exam will be dismissed from the PhD program for failure to progress. Such students may be allowed to complete a master's degree in Electrical Engineering.

Upon completion of the qualifying examination and after securing agreement by two faculty members to serve as dissertation advisor and second reader, respectively, the student files an Application for Candidacy for Doctoral Degree. The dissertation advisor must be a member of the Academic Council. One of the two faculty members must have either a full or a joint appointment in the Electrical Engineering Department. Students must advance to candidacy before the end of their second year in the graduate program. Students who do not advance to candidacy by the end of their second year will be dismissed from the PhD program for failure to progress. Such students may be allowed to complete a master's degree in Electrical Engineering instead.

After receiving department approval of the Application for Candidacy, the student becomes a candidate for the PhD degree.

Oral Exam
Type
Completion Requirement

Oral Exam

Fulfill ALL of the following requirements:

Reading Committee Form

Form a Dissertation Reading Committee of at least three members, including your Dissertation Advisor, in your third year and submit the Doctoral Dissertation Reading Committee Form to the Degree Progress Officer.

- Two of the three must belong to the EE faculty (full or joint appointment), and the dissertation advisor and second reader must be on the Academic Council.
- See the EE Graduate Handbook for more information about the Reading Committee.

AND

Oral Exam

Complete the University Oral Examination in the fourth year.

The oral examination is intended to verify that the student's research represents their contribution to knowledge and understanding of the research. The oral examination is a dissertation defense in which the candidate is expected to:

- Demonstrate their ability to explain and defend the thesis and its contribution to knowledge before experts in the field.
- Present a coherent picture of the research and its setting to scholars whose particular areas of interest lie outside the candidate's area of research.

- EE258 - Introduction to Radar Remote Sensing
- EE259 - Principles of Sensing for Autonomy
- EE262 - Three-Dimensional Imaging (Inactive)
- EE293B - Fundamentals of Energy Processes
- EE303 - Autonomous Implantable Systems
- EE309A - Semiconductor Memory Devices and Circuit Design
- EE309B - Emerging Non-Volatile Memory Devices and Circuit Design
- EE311 - Advanced Integrated Circuits Technology
- EE312 - Integrated Circuit Fabrication Laboratory
- EE316 - Advanced VLSI Devices
- EE317 - Special Topics on Wide Bandgap Materials and Devices
- EE320 - Nanoelectronics (Inactive)
- EE323 - Energy in Electronics
- EE327 - Properties of Semiconductor Materials (Inactive)
- EE329 - The Electronic Structure of Surfaces and Interfaces
- EE332 - Laser Dynamics
- EE336 - Nanophotonics
- EE340 - Quantum Photonics
- EE346 - Introduction to Nonlinear Optics
- EE347 - Optical Methods in Engineering Science
- EE348 - Advanced Optical Fiber Communications
- EE349 - Advanced Topics in Nano-Optics and Plasmonics (Inactive)
- ENERGY201C - Energy storage and conversion systems: Solar Cells, Fuel Cells, Batteries
- ENGR240 - Introduction to Micro and Nano Electromechanical Systems
- ENGR241 - Advanced Micro and Nano Fabrication Laboratory
- MATSCI209 - Electronic and Optical Properties of Solids
- MATSCI347 - Magnetic materials in nanotechnology, sensing, and energy (Inactive)
- OPHT207 - Introduction to Electro-neural Interfaces
- RAD235 - Advanced Ultrasound Imaging
- AA116Q - Electric Automobiles and Aircraft (Inactive)

AND

Depth Area 5: Signal Processing, Control and Optimization

Complete at least 4 of the following courses:

- AA203 - Optimal and Learning-based Control
- AA212 - Advanced Feedback Control Design
- CEE272R - Engineering Future Electricity Systems
- CS234 - Reinforcement Learning
- CS238 - Decision Making under Uncertainty
- CS326 - Topics in Advanced Robotic Manipulation
- EE227 - Robot Perception
- EE258 - Introduction to Radar Remote Sensing
- EE259 - Principles of Sensing for Autonomy
- EE260A - Principles of Robot Autonomy I
- EE260B - Principles of Robot Autonomy II
- EE261 - The Fourier Transform and Its Applications
- EE262 - Three-Dimensional Imaging (Inactive)
- EE263 - Introduction to Linear Dynamical Systems

- Answer satisfactorily any questions deemed pertinent by the examining committee.

Additional Comments:
Reading Committee Form
Form a Dissertation Reading Committee of at least three members, including your Dissertation Advisor, in your third year and submit the Doctoral Dissertation Reading Committee Form to the Degree Progress Officer.

- Two of the three must belong to the EE faculty (full or joint appointment), and the dissertation advisor and second reader must be on the Academic Council.
- See the EE Graduate Handbook for more information about the Reading Committee.

Oral Examination
Complete the University Oral Examination in the fourth year. The oral examination is intended to verify that the student's research represents their contribution to knowledge and understanding of the research. The oral examination is a dissertation defense in which the candidate is expected to:

- Demonstrate their ability to explain and defend the thesis and its contribution to knowledge before experts in the field.
- Present a coherent picture of the research and its setting to scholars whose particular areas of interest lie outside the candidate's area of research.
- Answer satisfactorily any questions deemed pertinent by the examining committee.

Dissertation
Type
Completion Requirement

Additional Comments:
The doctoral dissertation is the most essential part of a PhD program, which the reading committee must approve. The university Registrar provides specific instructions for the Dissertation and Thesis Submission.

Program Policies

External Credit Policies
3.2.1 Residency Policy for Graduate Students: Policy | Graduate Academic Policies and Procedures (stanford.edu)
Advising Expectations
See Graduate Advising for a statement of university policy on graduate advising.

The Department of Electrical Engineering is committed to providing academic advising in support of doctoral student scholarly and professional development. When most effective, this advising relationship entails collaborative and sustained engagement by both advisor and advisee. Students are expected to meet with their PhD dissertation advisor at least once per year. Students who do not have a dissertation advisor are encouraged to check in with their program advisor. As a best practice, advising expectations should be periodically discussed and reviewed to ensure mutual understanding. Both advisor and advisee are expected to maintain professionalism, respect, and integrity. They should also be responsive to one another promptly.

Faculty advisors guide students in critical areas such as selecting courses, designing and conducting research, developing teaching pedagogy, navigating policies and degree requirements, and exploring

- EE264 - Digital Signal Processing
- EE267 - Virtual Reality
- EE268 - The Engineering Economics of Electricity Markets
- EE269 - Signal Processing for Machine Learning
- EE270 - Large Scale Matrix Computation, Optimization and Learning
- EE277 - Bandit Learning: Behaviors and Applications
- EE278 - Probability and Statistical Inference
- EE219 - 3D+ Imaging Sensors
- EE355 - Imaging Radar and Applications
- EE364A - Convex Optimization I
- EE364B - Convex Optimization II
- EE367 - Computational Imaging
- EE368 - Digital Image Processing (Inactive)
- EE369A - Medical Imaging Systems I
- EE369B - Medical Imaging Systems II
- EE369C - Medical Image Reconstruction
- EE370 - Reinforcement Learning: Behaviors and Applications
- EE373A - Adaptive Signal Processing (Inactive)
- EE377 - Information Theory and Statistics
- EE378A - Statistical Signal Processing
- EE378B - Inference, Estimation, and Information Processing (Inactive)
- EE378C - Information-theoretic Lower Bounds in Data Science (Inactive)
- EE381 - Sensorimotor Learning for Embodied Agents
- EE469B - RF Pulse Design for Magnetic Resonance Imaging
- ENGR205 - Introduction to Control Design Techniques
- ENGR209A - Analysis and Control of Nonlinear Systems
- MS&E310 - Linear Programming
- MS&E311 - Optimization
- MS&E321 - Stochastic Systems
- MS&E322 - Stochastic Calculus and Control
- MS&E351 - Dynamic Programming and Stochastic Control (Inactive)
- MUSIC422 - Perceptual Audio Coding
- OIT604 - Data, Learning, and Decision-Making
- PSYCH221 - Image Systems Engineering
- STATS315A - Modern Applied Statistics: Learning
- STATS315B - Modern Applied Statistics: Learning II

All depth units must be letter graded.

Breadth Requirements

- Completing nine additional units from any area list other than the chosen depth area
- All breadth units must be letter graded and at the 200-level or above
- If a course is listed in the chosen depth area, it cannot be used to count in the breadth area

Complete ALL of the following :

Technical Course Requirement

Completion of 15 units of courses in engineering, natural sciences, mathematics, or statistics

- At least nine of the 15 units must be lecture courses at the

pedagogy, navigating policies and degree requirements, and exploring academic opportunities and professional pathways. The Department's Graduate Handbook provides information and suggested timelines for different stages of the doctoral program. For more information, see the department's Graduate Degree Progress website.

PhD students are initially assigned a program advisor based on the interests expressed in their application. This faculty member provides initial guidance in course selection, exploring academic opportunities and professional pathways, and identifying doctoral research opportunities. The department does not require formal lab rotations, but students are encouraged to consider exploring research activities in two or three labs during their first academic year.

Students identify their doctoral research/thesis advisor, pass the qualifying exam, and advance to candidacy before the end of the second year of study. The research supervisor assumes primary responsibility for the student's future direction, taking on the roles previously filled by the program advisor and ultimately directing the student's dissertation. Most students find an advisor from among the primary faculty members of the department. The research advisor may alternatively be a faculty member from another Stanford department familiar with supervising doctoral students and can provide both advising and funding for the duration of the doctoral program. When the research advisor is from outside the department, the student still maintains the previous program advisor from the primary faculty to guide departmental requirements and opportunities.

The faculty Associate Chair of Graduate Education is available during the academic year by email and during office hours. The department's student services office is also an essential part of the doctoral advising team: they inform students and advisors about university and department requirements, procedures, and opportunities, and they maintain the official records of advising assignments and approvals. Students are encouraged to talk with their doctoral program advisor, the Graduate Student Teaching Advisor, and the Degree Progress Officer from the student services office as they consider advisor selection or for guidance in working with their advisor(s).

The department's doctoral students are active contributors to the advising relationship, proactively seeking academic and professional guidance and taking responsibility for informing themselves of policies and degree requirements for their graduate program. See the Electrical Engineering Department Graduate Handbook (pdf) for more information.

Learning Outcomes

Program Learning Outcomes

The PhD is conferred upon candidates demonstrating substantial scholarship and the ability to conduct independent research. The program prepares students to make original contributions to Electrical Engineering and related fields through coursework and guided research.

- At least nine of the 15 units must be lecture courses at the 200-level or above
- EE courses must be 200-level or above
- A maximum of six units can be graduate-level independent study and/or 100-level courses; all units must be letter-graded
- All technical units must be letter-graded

Complete ALL of the following :

- Independent study units may not be taken in place of the nine units of 200-level or above letter-graded lecture courses.
- Mathematics, natural sciences, or engineering courses are acceptable, provided they use quantitative or scientific methods to analyze, design, or optimize artificial or natural systems. Courses primarily addressing entrepreneurship, management, economics, collaboration, design philosophy, language, or public speaking are typically unacceptable. Consult with your advisor or the Degree Progress Officer before selecting courses in Economics, GSB, d.school, MS&E, Psychology, or other departments offering semi-technical or non-technical courses.

Other Courses

Completion of at least nine additional units. These units must be at the 100-level or above and letter-graded or CR/NC in EE or other departments relevant to the EE MS degree and at the graduate level.

Complete ALL of the following :

Suggested courses include:

- Depth/breadth courses
- Additional technical courses
- Independent study (e.g., EE 390, EE 391)
- Curricular Practical Training (e.g., EE 290A)
- Seminars
- Entrepreneurial or design courses

Please note: Athletics courses do not count toward the 45 units. EFSLANG (English for Foreign Students) courses do not count toward the 45 units. If the university requires you to take any of these classes, they are additional units above the required 45 units.

All units must be at the 100 level or higher. No courses numbered below the 100 level can count toward a graduate degree. Note: Athletics courses do not count toward the 45 units. EFSLANG (English for Foreign Students) courses do not count toward the 45 units. If the university requires you to take any of these classes, they are additional units above the required 45 units.

All units must be at the 100 level or higher. No courses numbered below the 100 level can count toward a graduate degree.

Additional Comments:

Master of Science with Distinction in Research

A student who wishes to pursue the MS in Electrical Engineering (EE) with distinction in research must first identify a faculty advisor who agrees to supervise and support the research work. The research advisor must be a member of the Academic Council and must hold an appointment in Electrical Engineering. The student and principal advisor must also identify another faculty member who need not be in the Department of Electrical Engineering to serve as a secondary advisor and reader for the research report. In addition, the student must complete the following requirements beyond those for the regular MS in EE degree:

1. Research Experience – The program must include significant research experience at the level of a half-time commitment over the three academic quarters. In any given quarter, the half-time research commitment may be satisfied by:
   a. 50 percent appointment to a departmentally supported research assistantship
   b. Six (6) units of independent study (EE 300 or EE 391)
   c. A prorated combination of the two (such as a 25 percent research assistantship supplemented by three (3) units of independent study)
   d. An equivalent research experience while fully supported on a Stanford-funded or externally funded fellowship. Students and research advisors must document the planned research experience before the quarter starts and its completion at the end. Note: Fellowship must provide full support at the 10-unit tuition level and allow the student to pursue degree-related research in addition to their full-time course enrollment. This research must be carried out under the direction of the primary or secondary advisor.
2. Supervised Writing and Research – In addition to the research experience outlined in the previous requirement, students must enroll in at least three (3) units of independent research (EE 300 or EE 391) under the direction of their primary or secondary advisor. These units should be closely related to the research described in the first requirement but focused more on preparing the research report described in the next section. The writing and research units described in parts (1) and (2) may be counted toward the 45 units required for the degree.
3. All independent study units (EE 300 or EE 391) must be taken for letter grades, and a GPA of 3.0 (B) or better must be maintained.
4. Research Report – Students must complete a significant report describing their research and its conclusions. The research report represents work publishable in a journal or at a high-quality conference, although it is presumably longer and more expansive in scope than a typical conference paper. A copy of the research report must be submitted to the student services office in the department three weeks before the beginning of the examination period in the student’s final quarter. The primary and secondary advisors must approve the research report before the distinction-in-research designation can be conferred.

Joint Degree MS/JD Program

The Department of Electrical Engineering (EE) and the School of Law offer a **joint degree program** leading to an MS degree in EE combined with a JD degree. The JD/MS program is designed for students who wish to prepare themselves for careers involving law and electrical engineering.

Students interested in this joint degree program must apply to and gain admission separately from the Department of Electrical Engineering and the School of Law and, as an additional step, secure consent from both academic units to pursue both degrees simultaneously. Interest in the program should be noted on a student’s application to each academic unit. A student currently enrolled in either the Department of Electrical Engineering or the School of Law may apply for admission to the other academic unit and joint degree status after commencing study in that unit.

Joint degree students may elect to begin their study in either the Department of Electrical Engineering or the School of Law. Faculty advisors from each academic unit participate in planning and supervising the student’s joint program. In the first year of the joint degree program, students must be enrolled full-time in the School of Law. Students must satisfy the JD and MS degree requirements specified in the Stanford Bulletin.

The Electrical Engineering Department approves courses from the Law School that may count toward the MS degree in Electrical Engineering, and the Law School approves courses from the Department of Electrical Engineering that may count toward the JD degree. In either case, approval may consist of a list applicable to all joint degree students or tailored to each student's program.

No more than 45 quarter hours of approved courses may be counted toward both degrees. No more than 36 quarter hours of courses that originate outside the School of Law may count toward the Law degree. To the extent that courses under this joint degree program originate outside the School of Law but count toward the Law degree, the School of Law credits permitted under Section 17(1) of the Law School Regulations shall be reduced on a unit-per-unit basis but not below zero.

The maximum number of School of Law units that may be counted toward the MS degree in Electrical Engineering is the greater of:

1. 12 units, or
2. The maximum number of units from courses outside of the Department that MS candidates in Electrical Engineering are permitted to count toward the MS degree under general departmental guidelines or as outlined in the case of a particular student's program.

Tuition and financial aid arrangements are typically administered through the school in which the student is enrolled.

Joint Degree MS/MBA Program

The **Joint MS in Electrical Engineering /MBA Degree Program (EE/MBA)** enables students to pursue simultaneously a Master of Business Administration at the Graduate School of Business (GSB) and a Master of Science in Electrical Engineering at the Stanford School of Engineering. Joint MS/MBA degree students will be interested in technology and leadership and want to become managers or entrepreneurs in technologically-inclined businesses. The Joint MS/MBA Degree Program requires an **application** to, and acceptance for admission by, the Electrical Engineering Department (EE) and the GSB. MS/MBA students typically apply to and gain approval for admission to both programs within the same year. However, it is possible for current EE (or MBA) students who previously did not apply for the joint degree option to apply for and pursue the Joint MS/MBA Degree Program. EE students in the second year and MBA students in the second year may not apply for the Joint MS/MBA Degree Program.

Additional information on the MS in Electrical Engineering/MBA Joint Degree Program and its requirements is available on the **Electrical Engineering Department's website.**

Program Policies

External Credit Policies

All 45 units must be completed at Stanford: 3.2.1 Residency Policy for Graduate Students: Policy | Graduate Academic Policies and Procedures (stanford.edu)

Advising Expectations

See Graduate Advising for a statement of university policy on graduate advising.

The Department of Electrical Engineering is committed to providing academic advising in support of MS students' education and professional development. When most effective, this advising relationship entails both advisor and advise collaborative engagement. As a best practice, advising expectations should be discussed and reviewed to ensure mutual understanding. Both advisor and advisee are expected to maintain professionalism, respect, and integrity. They should also be responsive to one another promptly.

At the start of graduate study, each student is assigned a master's program advisor: a faculty member who guides course selection and exploring academic opportunities and professional pathways. Students are expected to meet with the program advisor during the first quarter to discuss their proposed master's plan. Typically, the same faculty member serves as program advisor for the duration of the master's study. If students wish to change their program advisor, they may contact the Degree Progress Officer to initiate the change advisor process.

In addition to the program advisor, the Electrical Engineering Graduate Student Teaching Advisor is a peer advisor available to advise students on course selection and academic opportunities on and off campus.

The department's student services office is also essential for the master's advising team. They inform students and advisors about university and department requirements, procedures, and opportunities and maintain the official records of advising assignments and approvals. Their contact information can be found on the department's Graduate Degree Progress website.

Finally, graduate students are active contributors to the advising relationship, proactively seeking academic and professional guidance and taking responsibility for informing themselves of policies and degree requirements for their graduate program. See the Electrical Engineering Department Graduate Handbook (pdf) for more information.

Learning Outcomes

Program Learning Outcomes

The purpose of the master's program is to provide students with the knowledge and skills necessary for a professional career or doctoral studies. This is done through coursework providing specialization in one area of Electrical Engineering and breadth in several other areas. Areas of specialization include Circuits, Software and Hardware Systems, Communications and Networking, Physical Technology and Science, and Signal Processing, Control, and Optimization.

EE-PMN - Electrical Engineering (PhD Minor)

Overview

Program Overview

A PhD minor is a program of study outside of the student's major department (i.e., a student's home department). A minor is not a requirement for any degree but is available when agreed on by the student and their home department and minor department.

The student's home department determines the acceptance of the minor as part of the total PhD program.

Director of Graduate Studies
Brad Osgood

Undergraduate/Graduate
Graduate

Simple Requisites

Program Requirements

Type

Completion Requirement

Additional Comments:

For a minor in Electrical Engineering, the student must:

- Have the application for the PhD minor approved by the Electrical Engineering (EE) Department and major department.
- Complete at least 20 units of Electrical Engineering (EE) lecture courses at the 200-level or above. If students want to use non-EE courses toward the EE PhD minor, these courses must be approved.
  - 15 of the 20 units must be letter graded
  - Seminars do not count toward the 20 units
  - Independent study units do not count toward the 20 units
- Maintain a grade point average of at least 3.35 in these courses.

Program Policies

External Credit Policies

Per policy (GAP 4.5.1 Doctoral Degrees, Requirements), all of the coursework for a Ph.D. minor must be completed at Stanford.

Courses

EE100 - The Electrical Engineering Profession

Course Description

Lectures/discussions on topics of importance to the electrical engineering professional. Continuing education, professional societies, intellectual property and patents, ethics, entrepreneurial engineering, and engineering management.

Grading Basis

RSN - Satisfactory/No Credit

Units

Min	Max	Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
1	1	No	1

Course Component	Enrollment Optional?
Seminar	No

Does this course satisfy the University Language Requirement?

No

EE101A - Circuits I

Course Description

Introduction to circuit modeling and analysis. Topics include creating the models of typical components in electronic circuits and simplifying non-linear models for restricted ranges of operation (small signal model); and using network theory to solve linear and non-linear circuits under static and dynamic operations. Prerequisite: MATH 20 (or equivalent) is required, and ENGR 40M is strongly recommended.

Grading Basis

ROP - Letter or Credit/No Credit

Units

Min	Max	Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
4	4	No	4

Course Component	Enrollment Optional?
Lab Section	Yes
Lecture	No

This course has been approved for the following WAYS

Scientific Method and Analysis (SMA)

Does this course satisfy the University Language Requirement?

No

EE101B - Circuits II

Course Description

Continuation of EE101A. Introduction to circuit design for modern electronic systems. Modeling and analysis of analog gain stages, frequency response, feedback. Filtering and analog to digital conversion. Fundamentals of circuit simulation. Prerequisites: EE101A, EE102A. Recommended: MATH 53 or CME102.

Grading Basis

ROP - Letter or Credit/No Credit

Units

Min	Max	Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
4	4	No	4

Course Component	Enrollment Optional?
Lab Section	Yes
Lecture	No

This course has been approved for the following WAYS

Scientific Method and Analysis (SMA)

Does this course satisfy the University Language Requirement?

No

EE102A - Signals and Systems I

Course Description

Concepts and tools for continuous- and discrete-time signal and system analysis with applications in signal processing, communications, and control. Mathematical representation of signals and systems. Linearity and time invariance. System impulse and step responses. System frequency response. Frequency-domain representations: Fourier series and Fourier transforms. Filtering and signal distortion. Time/frequency sampling and interpolation. Continuous-discrete-time signal conversion and quantization. Discrete-time signal processing. Prerequisites: MATH 53 or CME 102. EE 102A may be taken concurrently with either course, provided students have proficiency in complex numbers.

Grading Basis

ROP - Letter or Credit/No Credit

Units

Min	Max	Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
4	4	No	4

Course Component	Enrollment Optional?
Lab Section	Yes
Lecture	No

This course has been approved for the following WAYS

Formal Reasoning (FR), Applied Quantitative Reasoning (AQR)

Does this course satisfy the University Language Requirement?

No

EE102B - Signals and Systems II

Course Description

Continuation of EE 102A. Concepts and tools for continuous- and discrete-time signal and system analysis with applications in communications, signal processing and control. Analog and digital modulation and demodulation. Sampling, reconstruction, decimation and interpolation. Finite impulse response filter design. Discrete Fourier transforms, applications in convolution and spectral analysis. Laplace transforms, applications in circuits and feedback control. Z transforms, applications in infinite impulse response filter design. Prerequisite: EE 102A.

Grading Basis

ROP - Letter or Credit/No Credit

Units

Min	Max
4	4

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	4

Course Component	Enrollment Optional?
Lab Section	Yes
Lecture	No

This course has been approved for the following WAYS

Applied Quantitative Reasoning (AQR), Formal Reasoning (FR)

Does this course satisfy the University Language Requirement?

No

EE104 - Introduction to Machine Learning

Course Description

Introduction to machine learning. Formulation of supervised and unsupervised learning problems. Regression and classification. Data standardization and feature engineering. Loss function selection and its effect on learning. Regularization and its role in controlling complexity. Validation and overfitting. Robustness to outliers. Simple numerical implementation. Experiments on data from a wide variety of engineering and other disciplines. Undergraduate students should enroll for 5 units, and graduate students should enroll for 3 units. Prerequisites: ENGR 108; EE 178 or CS 109; CS106A or equivalent.

Cross Listed Courses

CME107 MACHINE LEARNING

Grading Basis

ROP - Letter or Credit/No Credit

Units

Min	Max
3	5

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	5

Course Component	Enrollment Optional?
Lecture	No

Does this course satisfy the University Language Requirement?

No

EE108 - Digital System Design

Course Description

Digital circuit, logic, and system design. Digital representation of information. CMOS logic circuits. Combinational logic design. Logic building blocks, idioms, and structured design. Sequential logic design and timing analysis. Clocks and synchronization. Finite state machines. Microcode control. Digital system design. Control and datapath partitioning. Lab. *In Autumn, enrollment preference is given to EE majors. Any EE majors who must enroll in Autumn are invited to contact the instructor. Formerly EE 108A.

Grading Basis

ROP - Letter or Credit/No Credit

Units

Min	Max
5	5

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	5

Course Component	Enrollment Optional?
Lab Section	Yes
Lecture	No

EE109 - Digital Systems Design Lab

Course Description

The design of integrated digital systems encompassing both customized software and hardware. Software/hardware design tradeoffs. Algorithm design for pipelining and parallelism. System latency and throughput tradeoffs. FPGA optimization techniques. Integration with external systems and smart devices. Firmware configuration and embedded system considerations. Enrollment limited to 25; preference to graduating seniors. Prerequisites: 108B, and CS 106B or X.

Grading Basis

ROP - Letter or Credit/No Credit

Units

Min	Max
4	4

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	4

Course Component	Enrollment Optional?
Lab Section	Yes
Lecture	No

Does this course satisfy the University Language Requirement?

No

EE114 - Fundamentals of Analog Integrated Circuit Design

Course Description

Analysis and simulation of elementary transistor stages, current mirrors, supply- and temperature-independent bias, and reference circuits. Overview of integrated circuit technologies, circuit components, component variations and practical design paradigms. Differential circuits, frequency response, and feedback will also be covered. Performance evaluation using computer-aided design tools. Undergraduates must take EE 114 for 4 units. Prerequisite: 101B. GER:DB-EngrAppSci

Cross Listed Courses	Grading Basis
EE214A FUND OF ANLG INTEGRTD CIRC DES	RLT - Letter (ABCD/NP)

Units

Min	Max
3	4

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	4

Course Component	Enrollment Optional?
Discussion	Yes
Lecture	No

EE115 - Taking the Pulse of the Planet

Course Description

Grappling with the big questions of sustainability and climate change, requires that we have ways to measure ? as we cannot manage what we cannot measure. This course, Taking the Pulse of the Planet introduces a new research and teaching initiative at Stanford ? also called Taking the Pulse of the Planet, which has the following goal: to have in place a global network of satellite, airborne, land/water-based sensors to support the real-time adaptive management of planetary health and human activities. Measurements will be made at the spatial and temporal scales required to inform the development and implementation of new policies addressing critical issues related to climate change, sustainability, and equity. Tapping into rapid advancements in sensor technology and data science over the past decade, we can now image and monitor many components of the Earth system and human activities. With the launch of the Stanford Doerr School of Sustainability, we wish to celebrate, through this course, the powerful role that advancements in technology ? specifically sensors ? and advancements in data science are playing in addressing the global challenges in sustainability and climate change. This will be a lecture class for undergraduates and graduate students designed to introduce them to the incredible array of sensors and data sets now available. We will finish the quarter with group projects that will involve the making and deployment of sensors around campus. The course will be designed to accommodate students at any level, with any background, with no required pre-requisites. In most of the assignments, we will be using Google co-lab to work with various types of sensor data. We anticipate drawing to this course both data-science-savvy and data-science-interested students. Therefore, we have developed online modules that are designed to help any student get up to speed on the "jargon" and the computational approaches used in the class.

Cross Listed Courses	Grading Basis
GEOPHYS115 TAKING THE PULSE OF THE PLANET	ROP - Letter or Credit/No Credit

Units

Min	Max
3	3

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	3

Course Component	Enrollment Optional?
Lecture	No

No Requirements

This course has been approved for the following WAYS

Scientific Method and Analysis (SMA), Applied Quantitative Reasoning (AQR)

EE116 - Semiconductor Devices for Energy and Electronics

Course Description

The underpinnings of modern technology are the transistor (circuits), the capacitor (memory), and the solar cell (energy). EE 116 introduces the physics of their operation, their historical origins (including Nobel prize breakthroughs), and how they can be optimized for future applications. The class covers physical principles of semiconductors, including silicon and new material discoveries, quantum effects, band theory, operating principles, and device equations. Recommended (but not required) co-requisite: EE 65 or equivalent.

Grading Basis

ROP - Letter or Credit/No Credit

Units

Min	Max	Course Component	Enrollment Optional?
3	3	Lecture	No

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	3

This course has been approved for the following WAYS	Does this course satisfy the University Language Requirement?
Scientific Method and Analysis (SMA), Formal Reasoning (FR)	No

EE118 - Introduction to Mechatronics

Course Description

Technologies involved in mechatronics (intelligent electro-mechanical systems), and techniques to apply this technology to mecatronic system design. Topics include: electronics (A/D, D/A converters, op-amps, filters, power devices); software program design, event-driven programming; hardware and DC stepper motors, solenoids, and robust sensing. Large, open-ended team project. Prerequisites: ENGR 40, CS 106, or equivalents.

Cross Listed Courses	Grading Basis
ME210 INTRODUCTION TO MECHATRONICS	RLT - Letter (ABCD/NP)

Units

Min	Max	Course Component	Enrollment Optional?
4	4	Lecture	No

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	4

EE119 - 3D+ Imaging Sensors

Course Description

Formally EE 292Q. Introduction to operation principles and key performance aspects of 3D+ imaging sensors used widely in industry. Concepts include imaging physics, data acquisition and image formation methods, and signal and image quality metrics that are broadly applicable across sensor types. Practical examples and demonstrations of various sensors such as radar, acoustic, LIDAR, and ToF modules will be presented in class as well as through structured labs. Invited speakers will highlight emerging 3D+ imaging applications that these sensors are enabling today. Prerequisites: EE 101A or equivalent. EE 102A or equivalent.

Cross Listed Courses	Grading Basis
EE219 3D+ IMAGING SENSORS	ROP - Letter or Credit/No Credit

Units

Min	Max
3	4

Course Component	Enrollment Optional?
Lab Section	Yes
Lecture	No

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	4

Does this course satisfy the University Language Requirement?

No

EE11SC - Dream It, Build It!

Course Description

The world is filled with electronic devices! There seem to be more and more all the time. Wouldn't it be cool to hack and build stuff? Bend electronics to your will? Cloud connect your own stuff? Dream It, Build It is a great place to start. Designed for folks with no experience, it will take you from zero to capable in short order. We will show you some of the worst kept secrets of how things are built and help you build stuff of your own. We'll start out with some basics about how to build things, how to measure things, how to hook stuff together and end up being able to make cloud-connected gizmos. [This is a SOPHOMORE COLLEGE course. Visit soco.stanford.edu for full details.]

Grading Basis

RLT - Letter (ABCD/NP)

Units

Min	Max	Course Component	Enrollment Optional?
2	2	Sophomore College Seminar	No

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	2

EE124 - Introduction to Neuroelectrical Engineering

Course Description

Fundamental properties of electrical activity in neurons, technology for measuring and altering neural activity, and operating principles of modern neurological and neural prosthetic medical systems. Topics: action potential generation and propagation, neuro-MEMS and measurement systems, experimental design and statistical data analysis, information encoding and decoding, clinical diagnostic systems, and fully-implantable neural prosthetic systems design. Prerequisite: EE 101A and EE 102A.

Grading Basis

ROP - Letter or Credit/No Credit

Units

Min	Max	Course Component	Enrollment Optional?
3	3	Lecture	No

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	3

This course has been approved for the following WAYS

Scientific Method and Analysis (SMA)

Does this course satisfy the University Language Requirement?

No

EE12Q - Science, Technology, Art

Course Description

This course presents the interwoven histories of science, technology, and art starting in the late Medieval period in Europe, through the Renaissance, up to the Modern era. It explores how advances in science and technology were exploited by artists and how problems confronted by artists were often solved by scientists and technologists, to the advancement of all. Topics include the geometry of perspective, optics of image making, chemistry of pigments and dyes, and the role of computing in art. A subsidiary theme is how artists indirectly interpreted scientific discoveries (telescope views of the heavens, microscope views of the teeny, Theory of Relativity, ...). Whenever possible, the technical evidence, developments, and of course art will be presented visually in the class.

Grading Basis

ROP - Letter or Credit/No Credit

Units

Min	Max	Course Component	Enrollment Optional?
3	3	SU Intro Seminar - Sophomore	No

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
Yes	3

Does this course satisfy the University Language Requirement?

No

EE133 - Analog Communications Design Laboratory

Course Description

Design, testing, and applications of Radio Frequency (RF) electronics: Amplitude Modulation (AM), Frequency Modulation (FM) and concepts of Software Define Radio (SDR) systems. Practical aspects of circuit implementations are developed; labs involve building and characterization of subsystems as well as integration of a complete radio system and a final project. Total enrollment limited to 25 students, undergraduate and graduate levels. Prerequisite: EE101B. Undergraduate students enroll in EE133 for 4 units and Graduate students enroll in EE233 for 3 units. Recommended: EE114/214A.

Cross Listed Courses

EE233 ANALOG COMMUN DESIGN LAB

Grading Basis

ROP - Letter or Credit/No Credit

Units

Min	Max	Course Component	Enrollment Optional?
3	4	Laboratory	No

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	4

Does this course satisfy the University Language Requirement?

No

EE134 - Introduction to Photonics

Course Description

Optics and photonics underpin the technologies that define our daily life, from communications and sensing to displays and imaging. This course provides an introduction to the principles that govern the generation, manipulation, and detection of light and will give students hands-on lab experience applying these principles to analyze and design working optical systems. The concepts we will cover form the basis for many systems in biology, optoelectronics, and telecommunications and build a foundation for further learning in photonics and optoelectronics. Connecting theory to observation and application is a major theme for the course. Prerequisite: EE 102A and one of the following: EE 42, Physics 43, or Physics 63.

Grading Basis

RLT - Letter (ABCD/NP)

Units

Min	Max	Course Component	Enrollment Optional?
4	4	Laboratory	No

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	4

This course has been approved for the following WAYS

Applied Quantitative Reasoning (AQR), Scientific Method and Analysis (SMA)

Does this course satisfy the University Language Requirement?

No

EE142 - Engineering Electromagnetics

Course Description

Introduction to electromagnetism and Maxwell's equations in static and dynamic regimes. Electrostatics and magnetostatics: Gauss's, Coulomb's, Faraday's, Ampere's, Biot-Savart's laws. Electric and magnetic potentials. Boundary conditions. Electric and magnetic field energy. Electrodynamics: Wave equation; Electromagnetic waves; Phasor form of Maxwell's equations.Solution of the wave equation in 1D free space: Wavelength, wave-vector, forward and backward propagating plane waves.Poynting's theorem. Propagation in lossy media, skin depth. Reflection and refraction at planar boundaries, total internal reflection. Solutions of wave equation for various 1D-3D problems: Electromagnetic resonators, waveguides periodic media, transmission lines. Formerly EE 141. Prerequisites: an introductory course in electromagnetics (PHYSICS 43, PHYSICS 63, PHYSICS 81, or EE 42) and a solid background in vector calculus (CME 100, CME 102, or MATH 52, with MATH 52 being an ideal prerequisite)

Grading Basis

RLT - Letter (ABCD/NP)

Units

Min	Max
3	3

Course Component	Enrollment Optional?
Lecture	No

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	3

This course has been approved for the following WAYS

Scientific Method and Analysis (SMA), Formal Reasoning (FR)

Does this course satisfy the University Language Requirement?

No

EE14N - Things about Stuff

Course Description

Preference to freshmen. The stories behind disruptive inventions such as the telegraph, telephone, wireless, television, transistor, and chip are as important as the inventions themselves, for they elucidate broadly applicable scientific principles. Focus is on studying consumer devices; projects include building batteries, energy conversion devices and semiconductors from pocket change. Students may propose topics and projects of interest to them. The trajectory of the course is determined in large part by the students themselves.

Grading Basis

ROP - Letter or Credit/No Credit

Units

Min	Max
3	3

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	3

Course Component	Enrollment Optional?
SU Intro Seminar - Freshman	No
Lab Section	No

This course has been approved for the following WAYS

Scientific Method and Analysis (SMA)

EE151 - Sustainable Energy Systems for South Africa

Course Description

This course addresses the question: How can South Africa realize it pledge to reduce global warming emissions by 2030 and beyond. The approach is to review the South Africa Energy Flow Diagram and determine system solutions to carbon emission reduction, assisted by a modeling program developed in the Hesselink group. The teaching approach involves lectures, field trips, consultations with energy leaders in South Africa, and small discussion groups involving students and teacher. The overarching objective of the course is to teach students to improve their ability to critically think about (energy) issues and solving problems.

Grading Basis

ROP - Letter or Credit/No Credit

Units

Min	Max
3	3

Course Component	Enrollment Optional?
Lecture	No

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	3

No Requirements

EE153 - Power Electronics

Course Description

Addressing the energy challenges of today and the environmental challenges of the future will require efficient energy conversion techniques. This course will discuss the circuits used to efficiently convert ac power to dc power, dc power from one voltage level to another, and dc power to ac power. The components used in these circuits (e.g., diodes, transistors, capacitors, inductors) will also be covered in detail to highlight their behavior in a practical implementation. A lab will be held with the class where students will obtain hands on experience with power electronic circuits. For WIM credit, students must enroll in EE 153 for 4 units. No exceptions. Formerly EE 292J. Prerequisite: EE 101A. Strongly recommended EE 101B.

Cross Listed Courses

EE253 POWER ELECTRONICS

Grading Basis

RLT - Letter (ABCD/NP)

Units

Min	Max
3	4

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	4

Course Component	Enrollment Optional?
Lab Section	Yes
Lecture	No

This course has been approved for the following WAYS

Scientific Method and Analysis (SMA)

Does this course satisfy the University Language Requirement?

No

EE156 - Board Level Design

Course Description

The ability to rapidly create board level electronics at prototype and short run volumes is enabling; Board Level Design teaches how to do this. This course focuses on applying circuit design concepts to rapidly create electronics to augment existing research instruments, explore and reduce technical risk, and provide engineering samples for evaluation. Students will send several PCBs for fabrication during the Quarter. The PCBs will be "brought-up" and tested to confirm functionality and performance to specification. Undergraduate EE majors will gain deeper exposure to circuits and planar electromagnetics. Students must enroll in EE 156 for 4 units and EE 256 for 3 units. Prerequisites: EE 42, EE 101A, and EE 108 or consent of instructor.

Cross Listed Courses

EE256 BOARD LEVEL DESIGN

Grading Basis

ROP - Letter or Credit/No Credit

Units

Min	Max
3	4

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	4

Course Component	Enrollment Optional?
Lab Section	Yes
Lecture	No

EE157 - Electric Motors for Renewable Energy, Robotics, and Electric Vehicles

Course Description

An introduction to electric motors and the principles of electromechanical energy conversion. Students will learn about, design, and build an electric motor system, choosing from one of three application areas: renewable energy (wind turbines), robotics (drones and precision manufacturing), or electric vehicles (cars, ships, and airplanes). Topics covered include ac and dc rotating machines, power electronics inverters and drives, and control techniques. Prerequisite: EE 42, Physics 43, ENGR 40M or equivalent.

Grading Basis

ROP - Letter or Credit/No Credit

Units

Min	Max
3	3

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	3

Course Component	Enrollment Optional?
Lab Section	Yes
Lecture	No

Does this course satisfy the University Language Requirement?

No

EE15Q - The Art and Science of Engineering Design

Course Description

The goal of this seminar is to introduce sophomores to the design process associated with an engineering project. The seminar will consist of a series of lectures. The first part of each lecture will focus on the different design aspects of an engineering project, including formation of the design team, developing a project statement, generating design ideas and specifications, finalizing the design, and reporting the outcome. Students will form teams to follow these procedures in designing a term project of their choice over the quarter. The second part of each lecture will consist of outside speakers, including founders of some of the most exciting companies in Silicon Valley, who will share their experiences about engineering design. On-site visits to Silicon Valley companies to showcase their design processes will also be part of the course. The seminar serves three purposes: (1) it introduces students to the design process of turning an idea into a final design, (2) it presents the different functions that people play in a project, and (3) it gives students a chance to consider what role in a project would be best suited to their interests and skills.

Grading Basis

RLT - Letter (ABCD/NP)

Units

Min	Max
3	3

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	3

Course Component	Enrollment Optional?
SU Intro Seminar - Sophomore	No

Does this course satisfy the University Language Requirement?

No

EE160A - Principles of Robot Autonomy I

Course Description

Basic principles for endowing mobile autonomous robots with perception, planning, and decision-making capabilities. Algorithmic approaches for robot perception, localization, and simultaneous localization and mapping; control of non-linear systems, learning-based control, and robot motion planning; introduction to methodologies for reasoning under uncertainty, e.g., (partially observable) Markov decision processes. Extensive use of the Robot Operating System (ROS) for demonstrations and hands-on activities. Prerequisites: CS 106A or equivalent, CME 100 or equivalent (for linear algebra), and CME 106 or equivalent (for probability theory).

Cross Listed Courses

AA174A PRINCIPLES OF ROBOT AUTONOMY I, CS137A PRINCIPLES OF ROBOT AUTONOMY I

Grading Basis

ROP - Letter or Credit/No Credit

Units

Min	Max
3	4

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	4

Course Component	Enrollment Optional?
Lecture	No

No Requirements

EE168 - Introduction to Digital Image Processing

Course Description

Computer processing of digital 2-D and 3-D data, combining theoretical material with implementation of computer algorithms. Topics: properties of digital images, design of display systems and algorithms, time and frequency representations, filters, image formation and enhancement, imaging systems, perspective, morphing, and animation applications. Instructional computer lab exercises implement practical algorithms. Final project consists of computer animations incorporating techniques learned in class. For WIM credit, students must enroll for 4 units. No exceptions. Prerequisite: Matlab programming.

Grading Basis

ROP - Letter or Credit/No Credit

Units

Min	Max	Course Component	Enrollment Optional?
3	4	Lecture	No

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	4

Does this course satisfy the University Language Requirement?

No

EE169 - Introduction to Bioimaging

Course Description

Bioimaging is important for both clinical medicine, and medical research. This course will provide a introduction to several of the major imaging modalities, using a signal processing perspective. The course will start with an introduction to multi-dimensional Fourier transforms, and image quality metrics. It will then study projection imaging systems (projection X-Ray), backprojection based systems (CT, PET, and SPECT), systems that use beam forming (ultrasound), and systems that use Fourier encoding (MRI). Prerequisites: EE102A, EE102B

Grading Basis

ROP - Letter or Credit/No Credit

Units

Min	Max	Course Component	Enrollment Optional?
3	3	Lecture	No

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	3

EE178 - Probabilistic Systems Analysis

Course Description

Introduction to probability and its role in modeling and analyzing real world phenomena and systems, including topics in statistics, machine learning, and statistical signal processing. Elements of probability, conditional probability, Bayes rule, independence. Discrete and continuous random variables. Signal detection. Functions of random variables. Expectation; mean, variance and covariance, linear MSE estimation. Conditional expectation; iterated expectation, MSE estimation, quantization and clustering. Parameter estimation. Classification. Sample averages. Inequalities and limit theorems. Confidence intervals. Prerequisites: Calculus at the level of MATH 51, CME 100 or equivalent and basic knowledge of computing at the level of CS106A.

Grading Basis

ROP - Letter or Credit/No Credit

Units

Min	Max	Course Component	Enrollment Optional?
3	4	Lecture	No

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	4

This course has been approved for the following WAYS	Does this course satisfy the University Language Requirement?
Formal Reasoning (FR), Applied Quantitative Reasoning (AQR)	No

EE179 - Analog and Digital Communication Systems

Course Description

This course covers the fundamental principles underlying the analysis, design and optimization of analog and digital communication systems. Design examples will be taken from the most prevalent communication systems today: cell phones, Wifi, radio and TV broadcasting, satellites, and computer networks. Analysis techniques based on Fourier transforms and energy/power spectral density will be developed. Mathematical models for random variables and random (noise) signals will be presented, which are used to characterize filtering and modulation of random noise. These techniques will then be used to design analog (AM and FM) and digital (PSK and FSK) communication systems and determine their performance over channels with noise and interference. Prerequisite: 102A.

Grading Basis

ROP - Letter or Credit/No Credit

Units

Min	Max	Course Component	Enrollment Optional?
3	3	Lecture	No

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	3

Does this course satisfy the University Language Requirement?

No

EE17N - Engineering the Micro and Nano Worlds: From Chips to Genes

Course Description

Preference to freshmen. The first part is hands-on micro- and nano-fabrication including the Stanford Nanofabrication Facility (SNF) and the Stanford Nanocharacterization Laboratory (SNL) and field trips to local companies and other research centers to illustrate the many applications; these include semiconductor integrated circuits ('chips'), DNA microarrays, microfluidic bio-sensors and microelectromechanical systems (MEMS). The second part is to create, design, propose and execute a project. Most of the grade will be based on the project. By the end of the course you will, of course, be able to read critically a New York Times article on nanotechnology. More importantly you will have experienced the challenge (and fun) of designing, carrying out and presenting your own experimental project. As a result you will be better equipped to choose your major. This course can complement (and differs from) the seminars offered by Profs Philip Wong and Hari Manoharan in that it emphasizes laboratory work and an experimental student-designed project. Prerequisites: high-school physics.

Grading Basis

ROP - Letter or Credit/No Credit

Units

Min	Max
3	3

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	3

Course Component	Enrollment Optional?
SU Intro Seminar - Freshman	No

Does this course satisfy the University Language Requirement?

No

EE180 - Digital Systems Architecture

Course Description

The design of processor-based digital systems. Instruction sets, addressing modes, data types. Assembly language programming, low-level data structures, introduction to operating systems and compilers. Processor microarchitecture, microprogramming, pipelining. Memory systems and caches. Input/output, interrupts, buses and DMA. System design implementation alternatives, software/hardware tradeoffs. Labs involve the design of processor subsystems and processor-based embedded systems. Formerly EE 108B. Prerequisite: one of CS107 or CS 107E (required) and EE108 (recommended but not required).

Cross Listed Courses

CS180 DIGITAL SYSTEMS ARCHITECTURE

Grading Basis

ROP - Letter or Credit/No Credit

Units

Min	Max
4	4

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	4

Course Component	Enrollment Optional?
Lab Section	Yes
Lecture	No

This course has been approved for the following WAYS

Scientific Method and Analysis (SMA)

Does this course satisfy the University Language Requirement?

No

EE184 - Internet Principles and Protocols

Course Description

This course covers the basic functions underlying computer networks and their organization into a layered architecture. The principles set forth for internetworking that allowed the Internet to be open and scalable are highlighted. Addressing in the Internet, the Internet Protocol (IP), the Transmission Control Protocol (TCP), and the various routing protocols used in the Internet are examined. The course also examines the design of specific prevalent networks (Ethernet and Wi-Fi, in particular) addressing both Physical Layer functionality (how bits are signaled on the transmission medium) and Media Access Control (MAC) Layer functionality which comprises how stations are addressed, the protocol according to which stations access a common shared transmission medium, and various management functions necessary for the operation of the network).

Grading Basis

ROP - Letter or Credit/No Credit

Units

Min	Max
3	3

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	3

Course Component	Enrollment Optional?
Lecture	No

EE185 - Interactive Light Sculpture Project

Course Description

Design, prototype, build, refine, program, and install a large interactive light sculpture in the Packard Building to celebrate the 125th anniversary of the EE department. Students may take the course for 1, 2, or 3 quarters; each quarter focuses on a different phase of the project. Topics covered include energy budgeting, communication, enclosure design, scalability, timing, circuit design, structural design, and safety. Prerequisite: ENGR 40M, or an introductory EE or CS course in circuits or programming.

Grading Basis

ROP - Letter or Credit/No Credit

Units

Min	Max
3	3

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
Yes	9

Course Component	Enrollment Optional?
Lab Section	Yes
Lecture	No

Does this course satisfy the University Language Requirement?

No

EE186 - Introduction to Embedded Systems

Course Description

This course introduces embedded systems and provides a comprehensive understanding of the key principles, including specification, design, development, and testing. Topics covered include, but are not limited to, clocks, GPIO, interrupts, buses, and storage. A modern microcontroller will be used as the target environment for a series of laboratory projects and a comprehensive final project. Prerequisite: CS 106B

Grading Basis

ROP - Letter or Credit/No Credit

Units

Min	Max
4	4

Course Component	Enrollment Optional?
Lab Section	Yes
Lecture	No

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	4

This course has been approved for the following WAYS

Scientific Method and Analysis (SMA)

Does this course satisfy the University Language Requirement?

No

EE190 - Special Studies or Projects in Electrical Engineering

Course Description

Independent work under the direction of a faculty member. Individual or team activities involve lab experimentation, design of devices or systems, or directed reading. Course may be repeated for credit.

Grading Basis

RSN - Satisfactory/No Credit

Units

Min	Max
1	15

Course Component	Enrollment Optional?
Individual Study	No

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
Yes	999

Does this course satisfy the University Language Requirement?

No

EE191 - Special Studies and Reports in Electrical Engineering

Course Description

Independent work under the direction of a faculty member given for a letter grade only. If a letter grade given on the basis of required written report or examination is not appropriate, enroll in 190. Course may be repeated for credit.

Grading Basis

RLT - Letter (ABCD/NP)

Units

Min	Max
1	15

Course Component	Enrollment Optional?
Individual Study	No

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
Yes	999

Does this course satisfy the University Language Requirement?

No

EE191A - Special Studies and Reports in Electrical Engineering

Course Description

EE191A is part of the Accelerated Calculus for Engineers program. Independent work under the direction of a faculty member given for a letter grade only. EE 191A counts as a Math one unit seminar course: it is this unit that constitutes the ACE program.

Grading Basis

RLT - Letter (ABCD/NP)

Units

Min	Max
1	1

Course Component	Enrollment Optional?
Individual Study	No

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	1

Does this course satisfy the University Language Requirement?

No

EE191W - Special Studies and Reports in Electrical Engineering (WIM)

Course Description

WIM-version of EE 191. For EE students using special studies (e.g., honors project, independent research project) to satisfy the writing-in-major requirement. A written report that has gone through revision with an adviser is required. An adviser from the Technical Communication Program is recommended.

Grading Basis

RLT - Letter (ABCD/NP)

Units

Min	Max	Course Component	Enrollment Optional?
3	10	Individual Study	No

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	10

Does this course satisfy the University Language Requirement?

No

EE195 - Electrical Engineering Instruction

Course Description

Students receive training from faculty or graduate student mentors to prepare them to assist in instruction of Electrical Engineering courses. The specific training and units of credit received are to be defined in consultation with one of the official instructors of EE 195. Note that University regulations prohibit students from being paid for the training while receiving academic credit for it. Enrollment limited.

Grading Basis

RSN - Satisfactory/No Credit

Units

Min	Max	Course Component	Enrollment Optional?
1	3	Individual Study	No

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	3

Does this course satisfy the University Language Requirement?

No

EE205 - Product Management for Electrical Engineers and Computer Scientists

Course Description

Successful products are the highest impact contribution anyone can make in product development. Students will learn to build successful products using fundamental concepts in Product Management. These include understanding customers, their job to be done, Identifying new product opportunities, and defining what to build that is technically feasible, valuable to the customer, and easy to use The course has two components, Product Management Project with corporate partners, and case-based classroom discussion of PM concepts and application. Prerequisite: Students must be currently enrolled in a MS or PhD engineering degree program.

Grading Basis

RLT - Letter (ABCD/NP)

Units

Min	Max	Course Component	Enrollment Optional?
3	3	Case/Problem Study	No

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	3

Does this course satisfy the University Language Requirement?

No

EE207 - Neuromorphics: Brains in Silicon

Course Description

While traversing through the natural world, you effortlessly perceive and react to a rich stream of stimuli. This constantly changing stream evokes spatiotemporal patterns of spikes that propagate through your brain from one ensemble of neurons to another. An ensemble may memorize a spatiotemporal pattern at the speed of life and recall it at the speed of thought. In the first half of this course, we will discuss and model how a neural ensemble memorizes and recalls such a spatiotemporal pattern. In the second half, we will explore how neuromorphic hardware could exploit these neurobiological mechanisms to run AI not with megawatts in the cloud but rather with watts on a smartphone. Prerequisites: Either computational modeling (BIOE 101, BIOE 300B) or circuit analysis (EE 101A).

Cross Listed Courses	Grading Basis
BIOE313 NEUROMORPHICS	RLT - Letter (ABCD/NP)

Units

Min	Max	Course Component	Enrollment Optional?
3	3	Lecture	No

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	3

Does this course satisfy the University Language Requirement?

No

EE212 - Integrated Circuit Fabrication Processes

Course Description

For students interested in the physical bases and practical methods of silicon VLSI chip fabrication, or the impact of technology on device and circuit design, or intending to pursue doctoral research involving the use of Stanford's Nanofabrication laboratory. Process simulators illustrate concepts. Topics: principles of integrated circuit fabrication processes, physical and chemical models for crystal growth, oxidation, ion implantation, etching, deposition, lithography, and back-end processing. Required for 410.

Grading Basis

ROP - Letter or Credit/No Credit

Units

Min	Max
3	3

Course Component	Enrollment Optional?
Lecture	No

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	3

Does this course satisfy the University Language Requirement?

No

EE214A - Fundamentals of Analog Integrated Circuit Design

Course Description

Analysis and simulation of elementary transistor stages, current mirrors, supply- and temperature-independent bias, and reference circuits. Overview of integrated circuit technologies, circuit components, component variations and practical design paradigms. Differential circuits, frequency response, and feedback will also be covered. Performance evaluation using computer-aided design tools. Undergraduates must take EE 114 for 4 units. Prerequisite: 101B. GER:DB-EngrAppSci

Cross Listed Courses	Grading Basis
EE114 FUND OF ANLG INTEGRTD CIRC DES	RLT - Letter (ABCD/NP)

Units

Min	Max
3	4

Course Component	Enrollment Optional?
Discussion	Yes
Lecture	No

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	4

EE214B - Advanced Integrated Circuit Design

Course Description

Analysis and design of analog and digital integrated circuits in advanced CMOS technology. Emphasis on compact modeling of performance limiting aspects and intuitive approaches to design. Analytical treatment of noise; analog circuit sizing using the transconductance to current ratio; analysis and design of feedback circuits. Delay analysis of digital logic gates; decoder design using logical effort. CMOS image sensors are used as a motivating application example. Prerequisites: EE114/214A.

Grading Basis

RLT - Letter (ABCD/NP)

Units

Min	Max
3	3

Course Component	Enrollment Optional?
Lecture	No

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	3

Does this course satisfy the University Language Requirement?

No

EE216 - Principles and Models of Semiconductor Devices

Course Description

Carrier generation, transport, recombination, and storage in semiconductors. Physical principles of operation of the p-n junction, heterojunction, metal semiconductor contact, bipolar junction transistor, MOS capacitor, MOS and junction field-effect transistors, and related optoelectronic devices such as CCDs, solar cells, LEDs, and detectors. First-order device models that reflect physical principles and are useful for integrated-circuit analysis and design. Prerequisite: 116 or equivalent.

Grading Basis

ROP - Letter or Credit/No Credit

Units

Min	Max
3	3

Course Component	Enrollment Optional?
Lecture	No

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	3

Does this course satisfy the University Language Requirement?

No

EE218 - Power Semiconductor Devices and Technology

Course Description

This course starts by covering the device physics and technology of current silicon power semiconductor devices including power MOSFETs, IGBTs, and Thyristors. Wide bandgap materials, especially GaN and SiC are potential replacements for Si power devices because of their fundamentally better properties. This course explores what is possible in these new materials, and what the remaining challenges are for wide bandgap materials to find widespread market acceptance in power applications. Future clean, renewable energy systems and high efficiency power control systems will critically depend on the higher performance devices possible in these new materials. Prerequisites: EE 116 or equivalent.

Grading Basis

ROP - Letter or Credit/No Credit

Units

Min	Max
3	3

Course Component	Enrollment Optional?
Lecture	No

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	3

Does this course satisfy the University Language Requirement?

No

EE219 - 3D+ Imaging Sensors

Course Description

Formally EE 292Q. Introduction to operation principles and key performance aspects of 3D+ imaging sensors used widely in industry. Concepts include imaging physics, data acquisition and image formation methods, and signal and image quality metrics that are broadly applicable across sensor types. Practical examples and demonstrations of various sensors such as radar, acoustic, LIDAR, and ToF modules will be presented in class as well as through structured labs. Invited speakers will highlight emerging 3D+ imaging applications that these sensors are enabling today. Prerequisites: EE 101A or equivalent. EE 102A or equivalent.

Cross Listed Courses

EE119 3D+ IMAGING SENSORS

Grading Basis

ROP - Letter or Credit/No Credit

Units

Min	Max
3	4

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	4

Course Component	Enrollment Optional?
Lab Section	Yes
Lecture	No

Does this course satisfy the University Language Requirement?

No

EE21N - Making at the nanometer scale: A journey into microchips

Course Description

Have you ever wondered what is inside your phone and your computer? What physical events happen in between the time you press the 'search' button and the information shows up on the screen? In this course, we start with the classic paper by Richard Feynman, "There's Plenty of Room at the Bottom," which laid down a challenge to the nanotechnologists. Today's microchips are nanotechnology in action. Transistors are nanometer scale. We will introduce students to the tools of nanotechnologists and the basic elements of nanoscale science and engineering such as nanotubes, nanowires, nanoparticles, and self-assembly. We will visit nanotechnology laboratories to consolidate our learning, go into the Stanford Nanofabrication Facility (SNF), and do a four-week project on nanofabrication. Hands-on laboratory work will be introduced (e.g., lithography, seeing things at the nanoscale using electron microscopes). We will learn how to build transistors from scratch and test them.

Grading Basis

RLT - Letter (ABCD/NP)

Units

Min	Max
3	3

Course Component	Enrollment Optional?
SU Intro Seminar - Freshman	No

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	3

This course has been approved for the following WAYS

Scientific Method and Analysis (SMA)

EE222 - Applied Quantum Mechanics I

Course Description

Emphasis is on applications in modern devices and systems. Topics include: Schr¿dinger's equation, eigenfunctions and eigenvalues, solutions of simple problems including quantum wells and tunneling, quantum harmonic oscillator, coherent states, operator approach to quantum mechanics, Dirac notation, angular momentum, hydrogen atom, calculation techniques including matrix diagonalization, perturbation theory, variational method, and time-dependent perturbation theory with applications to optical absorption, nonlinear optical coefficients, and Fermi's golden rule. Prerequisites: MATH 52 and 53, one of EE 65, ENGR 65, PHYSICS 71 (formerly PHYSICS 65), PHYSICS 70.

Cross Listed Courses

MATSCI201 EMPAPPLIED QUANTUM MECHANICS I

Grading Basis

ROP - Letter or Credit/No Credit

Units

Min	Max
3	3

Course Component	Enrollment Optional?
Lecture	No

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	3

Does this course satisfy the University Language Requirement?

No

EE223 - Applied Quantum Mechanics II

Course Description

Continuation of 222, including more advanced topics: quantum mechanics of crystalline materials, methods for one-dimensional problems, spin, systems of identical particles (bosons and fermions), introductory quantum optics (electromagnetic field quantization, coherent states), fermion annihilation and creation operators, interaction of different kinds of particles (spontaneous emission, optical absorption, and stimulated emission). Quantum information and interpretation of quantum mechanics. Other topics in electronics, optoelectronics, optics, and quantum information science. Prerequisite: 222.

Grading Basis

ROP - Letter or Credit/No Credit

Units

Min	Max	Course Component	Enrollment Optional?
3	3	Lecture	No

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	3

Does this course satisfy the University Language Requirement?

No

EE224 - Quantum Control and Engineering

Course Description

Introduction to quantum control, dynamics, and information processing, aimed at graduate students and advanced undergraduate students. Prerequisites include knowledge of quantum mechanics, linear algebra, and statistical analysis. The course will provide an overview of both the fundamentals and state-of-the-art techniques in the area of quantum engineering. Topics include qubits and operators, modeling and numerical analysis of open quantum systems, quantum control protocols, average Hamiltonian theory, dynamical decoupling, quantum device benchmarking, different quantum platforms and their applications.

Grading Basis

ROP - Letter or Credit/No Credit

Units

Min	Max	Course Component	Enrollment Optional?
3	3	Lecture	No

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	3

No Requirements

EE225 - Biochips and Medical Imaging

Course Description

The course covers state-of-the-art and emerging bio-sensors, bio-chips, imaging modalities, and nano-therapies which will be studied in the context of human physiology including the nervous system, circulatory system and immune system. Medical diagnostics will be divided into bio-chips (in-vitro diagnostics) and medical and molecular imaging (in-vivo imaging). In-depth discussion on cancer and cardiovascular diseases and the role of diagnostics and nano-therapies.

Cross Listed Courses

MATSCI225 BIOCHIPS AND MEDICAL IMAGING, SBIO225 BIOCHIPS AND MEDICAL IMAGING

Grading Basis

MOP - Medical Option (Med-Ltr-CR/NC)

Units

Min	Max	Course Component	Enrollment Optional?
3	3	Lecture	No

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	3

EE227 - Robot Perception

Course Description

Robot Perception is the cornerstone of modern robotics, enabling machines to interpret, understand, and respond to an array of sensory information they encounter. In the course, students will study the basic principles of typical sensor hardware on a robotics system (e.g., vision, tactile, and acoustic sensors), the algorithms that process the raw sensory data, and make actionable decisions from that information. Over the course of the semester, students will incrementally build their own vision-based robotics system in simulation via a series of homework coding assignments. Students enrolling 4 units will be required to submit an additional final written report. Prerequisites: This course requires programming experience in python as well as basic knowledge of linear algebra. Most of the required mathematical concepts will be reviewed, but it will be assumed that students have strong programming skills. All the homework requires extensive programming. Previous knowledge of robotics, machine learning or computer vision would be helpful but is not absolutely required.

Cross Listed Courses

CS227A ROBOT PERCEPTION

Grading Basis

ROP - Letter or Credit/No Credit

Units

Min	Max	Course Component	Enrollment Optional?
3	4	Lecture	No

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	4

No Requirements

EE228 - Basic Physics for Solid State Electronics

Course Description

Solid state devices have driven widespread technological revolution and are ubiquitous in our daily lives. We study the physics of solid state materials, enabling a complete understanding from the atom to the device. Topics include: energy band theory of solids; heterostructures and low-dimensional structures for bandgap engineering; electrons, holes, densities of states and relation to absorption and gain; and semiconductor statistics determining equilibrium and non-equilibrium carrier distributions. We explain how these principles govern the operation of modern devices, including transistors, light-emitting diodes and solar cells. Prerequisite: course in modern physics.

Grading Basis

ROP - Letter or Credit/No Credit

Units

Min	Max	Course Component	Enrollment Optional?
3	3	Lecture	No

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	3

Does this course satisfy the University Language Requirement?

No

EE233 - Analog Communications Design Laboratory

Course Description

Design, testing, and applications of Radio Frequency (RF) electronics: Amplitude Modulation (AM), Frequency Modulation (FM) and concepts of Software Define Radio (SDR) systems. Practical aspects of circuit implementations are developed; labs involve building and characterization of subsystems as well as integration of a complete radio system and a final project. Total enrollment limited to 25 students, undergraduate and graduate levels. Prerequisite: EE101B. Undergraduate students enroll in EE133 for 4 units and Graduate students enroll in EE233 for 3 units. Recommended: EE114/214A.

Cross Listed Courses	Grading Basis
EE133 ANALOG COMMUN DESIGN LAB	ROP - Letter or Credit/No Credit

Units

Min	Max	Course Component	Enrollment Optional?
3	4	Laboratory	No

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	4

Does this course satisfy the University Language Requirement?

No

EE234 - Photonics Laboratory

Course Description

Photonics and fiber optics with a focus on communication and sensing. Experimental characterization of semiconductor lasers, optical fibers, photodetectors, receiver circuitry, fiber optic links, optical amplifiers, and optical sensors and photonic crystals. Prerequisite: EE 236A (recommended).

Grading Basis

RLT - Letter (ABCD/NP)

Units

Min	Max	Course Component	Enrollment Optional?
3	3	Laboratory	No

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	3

EE235A - Analytical Methods in Biotechnology I

Course Description

This course provides fundamental principles underlying important analytical techniques used in modern biotechnology. The course comprises of lectures and hands-on laboratory experiments. Students will learn the core principles for designing, implementing and analyzing central experimental methods including polymerase chain reaction (PCR), electrophoresis, immunoassays, and high-throughput sequencing. The overall goal of the course is to enable engineering students with little or no background in molecular biology to transition into research in the field of biomedicine.

Grading Basis

RLT - Letter (ABCD/NP)

Units

Min	Max
3	3

Course Component	Enrollment Optional?
Lab Section	No
Lecture	No

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	3

Does this course satisfy the University Language Requirement?

No

EE236A - Modern Optics

Course Description

Geometrical optics; lens analysis and design, aberrations, optical instruments, radiometry. ray matrices. Wave nature of light; polarization, plane waves at interfaces and in media with varying refractive index, diffraction, Fourier Optics, Gaussian beams. Interference; single-beam interferometers (Fabry-Perot), multiple-beam interferometers (Michelson, Mach-Zehnder). Prerequisites: EE 142 or familiarity with electromagnetism and plane waves.

Grading Basis

RLT - Letter (ABCD/NP)

Units Min	Units Max	Course Component	Enrollment Optional?
3	3	Lecture	No

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	3

Does this course satisfy the University Language Requirement?

No

EE236B - Guided Waves

Course Description

Maxwell's equations, constitutive relations. Kramers-Kronig relations. Modes in waveguides: slab, rectangular, circular. Photonic crystals, surface plasmon modes. General properties of waveguide modes: orthogonality, phase and group indices, group velocity dispersion. Chirped pulse propagation in dispersive media and its connection to Gaussian beam propagation. Time lens. Waveguide technologies: glass, silicon, III-V semiconductor, metallic. Waveguide devices: fibers, lasers, modulators, arrayed waveguide gratings. Scattering matrix description of passive optical devices, and constraints from energy conservation, time-reversal symmetry and reciprocity. Mode coupling, directional couplers, distributed-feedback structures. Resonators from scattering matrix and input-output perspective. Micro-ring resonators. Prerequisites: EE 236A and EE 242 or familiarity with differential form of Maxwell's equations.

Grading Basis

ROP - Letter or Credit/No Credit

Units Min	Units Max	Course Component	Enrollment Optional?
3	3	Lecture	No

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	3

Does this course satisfy the University Language Requirement?

No

EE236C - Lasers

Course Description

Atomic systems, spontaneous emission, stimulated emission, amplification. Three- and four-level systems, rate equations, pumping schemes. Laser principles, conditions for steady-state oscillation. Transverse and longitudinal mode control and tuning. Exemplary laser systems: gas (HeNe), solid state (Nd:YAG, Ti:sapphire) and semiconductors. Elements of laser dynamics and noise. Formerly EE231. Prerequisites: EE 236B and familiarity with modern physics and semiconductor physics. Recommended: EE 216 and EE 223 (either may be taken concurrently).

Grading Basis

ROP - Letter or Credit/No Credit

Units Min	Units Max	Course Component	Enrollment Optional?
3	3	Lecture	No

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	3

Does this course satisfy the University Language Requirement?

No

EE237 - Solar Energy Conversion

Course Description

This course will be an introduction to solar photovoltaics. No prior photovoltaics knowledge is required. Class lectures will be supplemented by guest lectures from distinguished engineers, entrepreneurs and venture capitalists actively engaged in solar industry. Past guest speakers include Richard Swanson (CEO, SunPower), Benjamin Cook (Managing Partner at NextPower Capital) and Shahin Farshchi (Partner, Lux Capital). Topics Include: Economics of solar energy. Solar energy policy. Solar cell device physics: electrical and optical. Different generations of photovoltaic technology: crystalline silicon, thin film, multi-junction solar cells. Perovskite and silicon tandem cells. Advanced energy conversion concepts like photon up-conversion, quantum dot solar cells. Solar system issues including module assembly, inverters, micro-inverters and microgrid. No prior photovoltaics knowledge is required. Recommended: EE116, EE216 or equivalent.

Grading Basis

ROP - Letter or Credit/No Credit

Units Min	Units Max	Course Component	Enrollment Optional?
3	3	Lecture	No

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	3

Does this course satisfy the University Language Requirement?

No

EE238 - Introduction to Fourier Optics

Course Description

Fourier analysis applied to optical imaging. Theoretical topics include Fourier transform and angular spectrum to describe diffraction, Fourier transforming properties of lenses, image formation with coherent and incoherent light and aberrations. Application topics will cover image deconvolution/reconstruction, amplitude and phase pupil engineering, computational adaptive optics, and others motivated by student interest. Prerequisites: familiarity with Fourier transform and analysis, EE 102 and EE 142 or equivalent.

Grading Basis

RLT - Letter (ABCD/NP)

Units

Min	Max
3	3

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	3

Course Component	Enrollment Optional?
Lab Section	Yes
Lecture	No

Does this course satisfy the University Language Requirement?

No

EE242 - Electromagnetic Waves

Course Description

This course will provide an advanced treatment of electromagnetic waves in free space and media. The first part of the course will cover reflection, refraction, resonators, photonic crystals, and waveguides. The second part will cover finite-difference time-domain (FDTD) computation and introduce students to commercial FDTD software. The third part will focus on an analysis of EM waves in matter. The fourth part will cover potentials, Green's functions, far-field radiation, near-field radiation, antennas, and phased arrays. In lieu of a final exam, students will perform a group project demonstrating theoretical and application proficiency in a topic of their choosing. Homeworks and the final project will tie into real world applications of electromagnetics and utilize scientific computing (Matlab, Mathematica, or Python). Prerequisites: EE 142 or PHYSICS 120, and prior programming experience (Matlab or other language at level of CS 106A or higher).

Grading Basis

RLT - Letter (ABCD/NP)

Units

Min	Max
3	3

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	3

Course Component	Enrollment Optional?
Lecture	No

Does this course satisfy the University Language Requirement?

No

EE247 - Introduction to Optical Fiber Communications

Course Description

Fibers: single- and multi-mode, attenuation, modal dispersion, group-velocity dispersion, polarization-mode dispersion. Nonlinear effects in fibers: Raman, Brillouin, Kerr. Self- and cross-phase modulation, four-wave mixing. Sources: light-emitting diodes, laser diodes, transverse and longitudinal mode control, modulation, chirp, linewidth, intensity noise. Modulators: electro-optic, electro-absorption. Photodiodes: p-i-n, avalanche, responsivity, capacitance, transit time. Receivers: high-impedance, transimpedance, bandwidth, noise. Digital intensity modulation formats: non-return-to-zero, return-to-zero. Receiver performance: Q factor, bit-error ratio, sensitivity, quantum limit. Sensitivity degradations: extinction ratio, intensity noise, jitter, dispersion. Wavelength-division multiplexing. System architectures: local-area, access, metropolitan-area, long-haul. Prerequisites: EE 102A and EE 142.

Grading Basis

ROP - Letter or Credit/No Credit

Units

Min	Max
3	3

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	3

Course Component	Enrollment Optional?
Lecture	No

EE251 - High-Frequency Circuit Design Laboratory

Course Description

Students will study the theory of operation of instruments such as the time-domain reflectometer, sampling oscilloscope and vector network analyzer. They will build on that theoretical foundation by designing, constructing and characterizing numerous wireless building blocks in the upper-UHF range (e.g., up to about 500MHz), in a running series of laboratory exercises that conclude in a final project. Examples include impedance-matching and coupling structures, filters, narrowband and broadband amplifiers, mixers/modulators, and voltage-controlled oscillators. Prerequisite: EE 114 or EE 214A.

Grading Basis

RLT - Letter (ABCD/NP)

Units

Min	Max
3	3

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	3

Course Component	Enrollment Optional?
Lab Section	Yes
Lecture	No

Does this course satisfy the University Language Requirement?

No

EE253 - Power Electronics

Course Description

Addressing the energy challenges of today and the environmental challenges of the future will require efficient energy conversion techniques. This course will discuss the circuits used to efficiently convert ac power to dc power, dc power from one voltage level to another, and dc power to ac power. The components used in these circuits (e.g., diodes, transistors, capacitors, inductors) will also be covered in detail to highlight their behavior in a practical implementation. A lab will be held with the class where students will obtain hands on experience with power electronic circuits. For WIM credit, students must enroll in EE 153 for 4 units. No exceptions. Formerly EE 292J. Prerequisite: EE 101A. Strongly recommended EE 101B.

Cross Listed Courses

EE153 POWER ELECTRONICS

Grading Basis

RLT - Letter (ABCD/NP)

Units

Min	Max
3	4

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	4

Course Component	Enrollment Optional?
Lab Section	Yes
Lecture	No

This course has been approved for the following WAYS

Scientific Method and Analysis (SMA)

Does this course satisfy the University Language Requirement?

No

EE254 - Advanced Topics in Power Electronics

Course Description

In this course, we will study the practical issues related to the practical design of power electronic converters. We will also explore the trade-offs involved in selecting among the different circuits used to convert ac to dc, dc to ac and back to dc over a wide range of power levels suitable for different applications. In Advanced Topics in Power Electronic, as a multidisciplinary field, we will discuss power electronics circuits, extraction of transfer functions in Continuous and discontinuous conduction mode, voltage and current control of power converters, design of input/output filters to meet Electro Magnetic Interference specifications, layout of power electronics circuits and put this knowledge in a very practical context. Prerequisites: EE 153/253.

Grading Basis

RLT - Letter (ABCD/NP)

Units

Min	Max
3	3

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	3

Course Component	Enrollment Optional?
Lecture	No

Does this course satisfy the University Language Requirement?

No

EE256 - Board Level Design

Course Description

The ability to rapidly create board level electronics at prototype and short run volumes is enabling; Board Level Design teaches how to do this. This course focuses on applying circuit design concepts to rapidly create electronics to augment existing research instruments, explore and reduce technical risk, and provide engineering samples for evaluation. Students will send several PCBs for fabrication during the Quarter. The PCBs will be "brought-up" and tested to confirm functionality and performance to specification. Undergraduate EE majors will gain deeper exposure to circuits and planar electromagnetics. Students must enroll in EE 156 for 4 units and EE 256 for 3 units. Prerequisites: EE 42, EE 101A, and EE 108 or consent of instructor.

Cross Listed Courses

EE156 BOARD LEVEL DESIGN

Grading Basis

ROP - Letter or Credit/No Credit

Units

Min	Max
3	4

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	4

Course Component	Enrollment Optional?
Lab Section	Yes
Lecture	No

EE258 - Introduction to Radar Remote Sensing

Course Description

Introduction to the principles behind, and applications of, radar as a remote sensing tool. Radar observables and the radar equation, system and subsystem design, signal processing and matched filters, detection problems, radar imaging, range-Doppler processing, interaction of radar waves with Earth or planetary surfaces, interferometers. Applications include polarimetry for surface characterization, measurement of topography and surface change, moving object detection and motion measurements. Graduate/Advanced undergraduate level. Undergraduate students should enroll for 4 units, and graduate students should enroll for 3 units. Prerequisites: deterministic signal processing (EE 102A + B or equivalent); probability and estimation (EE 178 or equivalent).

Cross Listed Courses

GEOPHYS258J INTRO TO RADAR REMOTE SENSING

Grading Basis

ROP - Letter or Credit/No Credit

Units

Min	Max
3	4

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	4

Course Component	Enrollment Optional?
Lab Section	Yes
Lecture	No

EE259 - Principles of Sensing for Autonomy

Course Description

Basic principles of design and operation of sensors for autonomous systems. Global positioning system (GPS), inertial measurement unit (IMU), Ultrasonic sensor, camera, radar and lidar. Hardware architecture and signal processing algorithms for different sensors. Analysis of sensor performance under different operating conditions, and practical design tradeoffs. Sensor registration and calibration methods. Sensor fusion techniques. Prerequisites: EE 101B or equivalent, EE 102B or equivalent, EE 42 or equivalent, ENGR 108 or equivalent, basic programming (Python, Julia, MATLAB or equivalent).

Grading Basis

ROP - Letter or Credit/No Credit

Units

Min	Max
3	3

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	3

Course Component	Enrollment Optional?
Lecture	No

EE260A - Principles of Robot Autonomy I

Course Description

Basic principles for endowing mobile autonomous robots with perception, planning, and decision-making capabilities. Algorithmic approaches for robot perception, localization, and simultaneous localization and mapping; control of non-linear systems, learning-based control, and robot motion planning; introduction to methodologies for reasoning under uncertainty, e.g., (partially observable) Markov decision processes. Extensive use of the Robot Operating System (ROS) for demonstrations and hands-on activities. Prerequisites: CS 106A or equivalent, CME 100 or equivalent (for linear algebra), and CME 106 or equivalent (for probability theory).

Cross Listed Courses

ME274A PRINCIPLES OF ROBOT AUTONOMY I, AA274A PRINCIPLES OF ROBOT AUTONOMY I, CS237A PRINCIPLES OF ROBOT AUTONOMY I

Grading Basis

ROP - Letter or Credit/No Credit

Units

Min	Max
3	3

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	3

Course Component	Enrollment Optional?
Lecture	No

This course has been approved for the following WAYS

Applied Quantitative Reasoning (AQR)

EE260B - Principles of Robot Autonomy II

Course Description

This course teaches advanced principles for endowing mobile autonomous robots with capabilities to autonomously learn new skills and to physically interact with the environment and with humans. It also provides an overview of different robot system architectures. Concepts that will be covered in the course are: Reinforcement Learning and its relationship to optimal control, contact and dynamics models for prehensile and non-prehensile robot manipulation, imitation learning and human intent inference, as well as different system architectures and their verification. Students will earn the theoretical foundations for these concepts and implement them on mobile manipulation platforms. In homeworks, the Robot Operating System (ROS) will be used extensively for demonstrations and hands-on activities. Prerequisites: CS106A or equivalent, CME 100 or equivalent (for linear algebra), CME 106 or equivalent (for probability theory), and AA 171/274.

Cross Listed Courses	Grading Basis
ME274B PRINCIPLES ROBOT AUTONOMY II, CS237B PRINCIPLES ROBOT AUTONOMY II, AA174B PRINCIPLES ROBOT AUTONOMY II, AA274B PRINCIPLES ROBOT AUTONOMY II	ROP - Letter or Credit/No Credit

Units

Min	Max	Course Component	Enrollment Optional?
3	4	Lecture	No

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	4

Does this course satisfy the University Language Requirement?

No

EE261 - The Fourier Transform and Its Applications

Course Description

The Fourier transform as a tool for solving physical problems. Fourier series, the Fourier transform of continuous and discrete signals and its properties. The Dirac delta, distributions, and generalized transforms. Convolutions and correlations and applications; probability distributions, sampling theory, filters, and analysis of linear systems. The discrete Fourier transform and the FFT algorithm. Multidimensional Fourier transform and use in imaging. Further applications to optics, crystallography. Emphasis is on relating the theoretical principles to solving practical engineering and science problems. Prerequisites: Math through ODEs, basic linear algebra, Comfort with sums and discrete signals, Fourier series at the level of 102A

Grading Basis

ROP - Letter or Credit/No Credit

Units

Min	Max	Course Component	Enrollment Optional?
3	3	Lecture	No

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	3

Does this course satisfy the University Language Requirement?

No

EE263 - Introduction to Linear Dynamical Systems

Course Description

Applied linear algebra and linear dynamical systems with applications to circuits, signal processing, communications, and control systems. Topics: least-squares approximations of over-determined equations, and least-norm solutions of underdetermined equations. Symmetric matrices, matrix norm, and singular-value decomposition. Eigenvalues, left and right eigenvectors, with dynamical interpretation. Matrix exponential, stability, and asymptotic behavior. Multi-input/multi-output systems, impulse and step matrices; convolution and transfer-matrix descriptions. Control, reachability, and state transfer; observability and least-squares state estimation. Prerequisites: Linear algebra and matrices as in ENGR 108 or MATH 104; ordinary differential equations and Laplace transforms as in EE 102B or CME 102.

Cross Listed Courses	Grading Basis
CME263 INTRO LINEAR DYNAMICAL SYSTEMS	ROP - Letter or Credit/No Credit

Units

Min	Max
3	3

Course Component	Enrollment Optional?
Lecture	No

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	3

Does this course satisfy the University Language Requirement?

No

EE264 - Digital Signal Processing

Course Description

Digital signal processing (DSP) techniques and design of DSP applications. Topics include: discrete-time random signals; sampling and multi-rate systems; oversampling and quantization in A-to-D conversion; properties of LTI systems; quantization in fixed-point implementations of filters; digital filter design; discrete Fourier Transform and FFT; spectrum analysis using the DFT; parametric signal modeling and adaptive filtering. The course also covers applications of DSP in areas such as speech, audio and communication systems. The optional lab section (Section 02) provides a hands-on opportunity to explore the application of DSP theory to practical real-time applications in an embedded processing platform. See ee264.stanford.edu for more information. Register in Section 02 to take the lab. Undergraduate students taking the lab should register for 4 units to meet the EE design requirement. The optional lab section is not available to remote SCPD students. Prerequisites: EE 102A and EE 102B or equivalent, basic programming skills (Matlab and C++)

Grading Basis

ROP - Letter or Credit/No Credit

Units

Min	Max
3	4

Course Component	Enrollment Optional?
Lab Section	Yes
Lecture	No

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	4

Does this course satisfy the University Language Requirement?

No

EE264P - Digital Signal Processing Projects

Course Description

This is a companion course to EE 264 Digital Signal Processing for students interested in developing advanced DSP projects beyond the scope of the one credit hour EE 264 lab option (section 2). Weekly meetings with the instructor to plan the week ahead and to share results from the previous are mandatory and will be scheduled at a mutually convenient time. A final project report, project demonstration, and presentation is required. Instructor will determine appropriate number of units based on the project complexity. Prerequisite: EE 264 and instructor approval.

Grading Basis

RLT - Letter (ABCD/NP)

Units

Min	Max	Course Component	Enrollment Optional?
1	3	Laboratory	No

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	3

Simple Requisites

EE264P Prerequisite

Type

Prerequisite

Complete ALL of the following Courses:

- EE264 - Digital Signal Processing

Additional Comments:

EE264W - Digital Signal Processing (WIM)

Course Description

Writing in the Major (WIM) version of the 4-unit EE 264 theory + lab course. Digital signal processing (DSP) techniques and design of DSP applications. Topics include: discrete-time random signals; sampling and multi-rate systems; oversampling and quantization in A-to-D conversion; properties of LTI systems; quantization in fixed-point implementations of filters; digital filter design; discrete Fourier Transform and FFT; spectrum analysis using the DFT; parametric signal modeling and adaptive filtering. The course also covers applications of DSP in areas such as speech, audio and communication systems. The lab component provides a hands-on opportunity to explore the application of DSP theory to practical real-time applications in an embedded processing platform. See ee264.stanford.edu for more information. Prerequisites: EE 102A and EE 102B or equivalent, basic programming skills (Matlab and C++)

Grading Basis

ROP - Letter or Credit/No Credit

Units

Min	Max	Course Component	Enrollment Optional?
5	5	Lecture	No

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	5

Does this course satisfy the University Language Requirement?

No

EE267 - Virtual Reality

Course Description

OpenGL, real-time rendering, 3D display systems, display optics & electronics, IMUs and sensors, tracking, haptics, rendering pipeline, multimodal human perception and depth perception, stereo rendering, presence. Emphasis on VR technology. Hands-on programming assignments. The 3-unit version requires a final programming assignment in which you create your own virtual environment. The 4-unit version requires a final course project and written report in lieu of the final assignment. For WIM credit, students must enroll in EE 267W for 5 units. Prerequisites: Strong programming skills, ENGR 108 or equivalent. Helpful: basic computer graphics / OpenGL.

Grading Basis

ROP - Letter or Credit/No Credit

Units

Min	Max
3	4

Course Component	Enrollment Optional?
Lab Section	Yes
Lecture	No

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	4

Does this course satisfy the University Language Requirement?

No

EE267W - Virtual Reality (WIM)

Course Description

Writing in the Major (WIM) version of the 4-unit EE 267 theory + lab/project course. This course also meets the EE design requirement. Topics include: OpenGL, real-time rendering, 3D display systems, display optics & electronics, IMUs and sensors, tracking, haptics, rendering pipeline, multimodal human perception and depth perception, stereo rendering, presence. Emphasis on VR technology. Hands-on programming assignments. The 5-unit WIM version requires everything the 4-unit version does, i.e. a final course project and written report in lieu of the final assignment. The 5-unit WIM version additional requires participation in 2 writing in the major workshops, and weekly writing assignments. Prerequisites: Strong programming skills, ENGR 108 or equivalent. Helpful: basic computer graphics / OpenGL.

Grading Basis

ROP - Letter or Credit/No Credit

Units

Min	Max
5	5

Course Component	Enrollment Optional?
Lab Section	No
Lecture	No

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	5

Does this course satisfy the University Language Requirement?

No

EE268 - The Engineering Economics of Electricity Markets

Course Description

This course presents the power system engineering and economic concepts necessary to understand the costs and benefits of transitioning to a low carbon electricity supply industry. The technical characteristics of generation units and transmission and distribution networks as well as the mechanisms used to operate the electricity supply industries will be studied. The fundamental economics of wholesale markets and how intermittent renewables impact the price and quantity of physical and financial products traded in these markets (e.g., energy, capacity, ancillary services, and financial contracts) will be analyzed. Long-term resource adequacy mechanisms will be introduced and their properties analyzed. The role of both short-duration and seasonal energy storage will be analyzed. Mechanisms for determining the engineering and economic need for transmission network expansions in a wholesale market will be discussed. The impact of distributed versus grid-scale generation on the performance of electricity supply industries will be studied. A detailed treatment of electricity retailing will focus on the importance of active demand-side participation in a low carbon energy sector. This course uses knowledge of probability at the level of Stats 116, optimization at the level of MS&E 111, statistical analysis at the level of Economics 102B, microeconomics at the level of Economics 51 and computer programming in R.

Cross Listed Courses

ECON261 ENGR ECON ELECTRICITY MARKETS

Grading Basis

ROP - Letter or Credit/No Credit

Units

Min	Max	Course Component	Enrollment Optional?
3	3	Lecture	No

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	3

Simple Requisites

ECON189 Prerequisite

Type

Prerequisite

Fulfill ALL of the following requirements:

Familiarity with optimization using linear algebra

Complete at least 1 of the following courses:

- ENGR108 - Introduction to Matrix Methods
- MATH104 - Applied Matrix Theory

AND

Probability and statistical analysis

Complete at least 1 of the following courses:

- EE178 - Probabilistic Systems Analysis
- STATS116 - Theory of Probability (Inactive)

Additional Comments:

EE269 - Signal Processing for Machine Learning

Course Description

This course will introduce you to fundamental signal processing concepts and tools needed to apply machine learning to discrete signals. You will learn about commonly used techniques for capturing, processing, manipulating, learning and classifying signals. The topics include: mathematical models for discrete-time signals, vector spaces, Fourier analysis, time-frequency analysis, Z-transforms and filters, signal classification and prediction, basic image processing, compressed sensing and deep learning. This class will culminate in a final project. Prerequisites: EE 102A and EE 102B or equivalent, basic programming skills (Matlab). ENGR 108 and EE 178 are recommended.

Grading Basis

ROP - Letter or Credit/No Credit

Units

Min	Max	Course Component	Enrollment Optional?
3	3	Lecture	No

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	3

Does this course satisfy the University Language Requirement?

No

EE26N - The Wireless World, and the Data You Leak

Course Description

The world is increasingly based on wireless communication. Cell phones and WiFi are the most visible examples. Others are key fobs, water meters, gas and electric meters, garage door openers, baby monitors, and the list continues to expand. All of these produce RF signals you can detect and often decode. This seminar will explore how much information you broadcast throughout your day, and how it can easily be received and decoded using inexpensive hardware and public domain software. You will be able to explain why different information services use different frequencies, why they encode the information the way they do, and what security risks they present.

Grading Basis

ROP - Letter or Credit/No Credit

Units

Min	Max	Course Component	Enrollment Optional?
3	3	SU Intro Seminar - Freshman	No

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	3

Simple Requisites

EE 26N Prerequisite

Type

Prerequisite

EE 26N Prerequisite

Enrollment limited to undergraduate students.

Additional Comments:

EE270 - Large Scale Matrix Computation, Optimization and Learning

Course Description

Massive data sets are now common to many different fields of research and practice. Classical numerical linear algebra can be prohibitively costly in many modern problems. This course will explore the theory and practice of randomized matrix computation and optimization for large-scale problems to address challenges in modern massive data sets. Applications in machine learning, statistics, signal processing and data mining will be surveyed. Prerequisites: familiarity with linear algebra (ENGR 108 or equivalent), basic probability and statistics (EE 178 or equivalent), basic programming skills.

Grading Basis

ROP - Letter or Credit/No Credit

Units

Min	Max	Course Component	Enrollment Optional?
3	3	Lecture	No

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	3

Does this course satisfy the University Language Requirement?

No

EE271 - Introduction to VLSI Systems

Course Description

Provides a quick introduction to MOS transistors and IC fabrication and then creates abstractions to allow you to create and reason about complex digital systems. It uses a switch resistor model of a transistor, uses it to model gates, and then shows how gates and physical layout can be synthesized from Verilog or SystemVerilog descriptions. Most of the class will be spent on providing techniques to create designs that can be validated, are low power, provide good performance, and can be completed in finite time. Prerequisites: 101A and 108; familiarity with transistors, logic design, Verilog and digital system organization

Grading Basis

ROP - Letter or Credit/No Credit

Units

Min	Max	Course Component	Enrollment Optional?
3	3	Lecture	No

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	3

Does this course satisfy the University Language Requirement?

No

EE272 - Design Projects in VLSI Systems I

Course Description

This course will introduce you to mixed signal design and the electronic design automation (EDA) tools used for it. Working in teams, you will create a chip with a digital deep neural network (DNN) accelerator and a small analog block using a modern design flow and EDA tools. The project involves writing a synthesizable C++ and a Verilog model of your chip, creating a testing/debug strategy for your chip, wrapping custom layout to fit into a standard cell system, using synthesis and place and route tools to create the layout of your chip, and understanding all the weird stuff you need to do to tape-out a chip. Useful for anyone who will build a chip in their Ph.D. Pre-requisites: EE271 and experience in digital/analog circuit design.

Grading Basis

ROP - Letter or Credit/No Credit

Units

Min	Max	Course Component	Enrollment Optional?
3	4	Lecture	No

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	4

Does this course satisfy the University Language Requirement?

No

EE273 - Digital Systems Engineering

Course Description

Electrical issues in the design of high-performance digital systems, including signaling, timing, synchronization, noise, and power distribution. High-speed signaling methods; noise in digital systems, its effect on signaling, and methods for noise reduction; timing conventions; timing noise (skew and jitter), its effect on systems, and methods for mitigating timing noise; synchronization issues and synchronizer design; clock and power distribution problems and techniques; impact of electrical issues on system architecture and design. Prerequisites: EE101A and EE108A. Recommended: EE114/214A.

Grading Basis

ROP - Letter or Credit/No Credit

Units

Min	Max	Course Component	Enrollment Optional?
3	3	Lecture	No

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	3

Does this course satisfy the University Language Requirement?

No

EE274 - Data Compression: Theory and Applications

Course Description

The course focuses on the theory and algorithms underlying modern data compression. The first part of the course introduces techniques for entropy coding and for lossless compression. The second part covers lossy compression including techniques for multimedia compression. The last part of the course will cover advanced theoretical topics and applications, such as neural network based compression, distributed compression, and computation over compressed data. Prerequisites: basic probability and programming background (EE178, CS106B or equivalent), a course in signals and systems (EE102A), or instructor's permission.

Grading Basis

ROP - Letter or Credit/No Credit

Units

Min	Max	Course Component	Enrollment Optional?
3	3	Lecture	No

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	3

EE276 - Information Theory

Course Description

(Formerly EE 376A.) Information theory was invented as a mathematical theory for communication but has subsequently found a broad range of applications. We study how to measure, represent, and communicate information effectively: from the foundational concepts of entropy and mutual information to the fundamental role they play in data representation, communication, inference, practical compression and error correction. As time allows, we cover relations and applications to other areas such as probability, statistics, learning and genomics. Prerequisite: a first undergraduate course in probability.

Grading Basis

ROP - Letter or Credit/No Credit

Units

Min	Max	Course Component	Enrollment Optional?
3	3	Lecture	No

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	3

Does this course satisfy the University Language Requirement?

No

EE277 - Bandit Learning: Behaviors and Applications

Course Description

The subject of reinforcement learning addresses the design of agents that improve decisions over time while operating within complex and uncertain environments. This first course of the sequence restricts attention to the special case of bandit learning, which focuses on environments in which all consequences of an action are realized immediately. This course covers desired agent behaviors and principled scalable approaches to realizing such behavior. Topics include learning from trial and error, exploration, contextualization, generalization, and representation learning. Motivating examples will be drawn from recommendation systems, crowdsourcing, education, and generative artificial intelligence. Homework assignments primarily involve programming exercises carried out in Colab, using the python programming language and standard libraries for numerical computation and machine learning. Prerequisites: programming (e.g., CS106B), probability (e.g., MS&E 121, EE 178 or CS 109), machine learning (e.g., EE 104/ CME 107, MS&E 226 or CS 229).

Cross Listed Courses

MS&E237A BANDIT LEARNING

Grading Basis

ROP - Letter or Credit/No Credit

Units

Min	Max	Course Component	Enrollment Optional?
3	3	Lecture	No

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	3

Does this course satisfy the University Language Requirement?

No

EE278 - Probability and Statistical Inference

Course Description

Many engineering applications require efficient methods to process, analyze, and infer signals, data and models of interest that are best described probabilistically. Building on a first course in probability (such as EE178 or equivalent), this course introduces more advanced topics in probability such as concentration inequalities, random vectors and random processes, and explores their applications in statistics, machine learning and signal processing. Specific applications include hypothesis testing and classification; dimensionality reduction and generalization in machine learning, minimum mean square error estimation and Kalman filtering. Prerequisites: EE178 or equivalent

Grading Basis

ROP - Letter or Credit/No Credit

Units Min	Units Max	Course Component	Enrollment Optional?
3	3	Lecture	No

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	3

Does this course satisfy the University Language Requirement?

No

EE279 - Introduction to Digital Communication

Course Description

Digital communication is a rather unique field in engineering in which theoretical ideas have had an extraordinary impact on the design of actual systems. The course provides a basic understanding of the analysis and design of digital communication systems, building on various ideas from probability theory, stochastic processes, linear algebra and Fourier analysis. Topics include: detection and probability of error for binary and M-ary signals (PAM, QAM, PSK), receiver design and sufficient statistics, controlling the spectrum and the Nyquist criterion, bandpass communication and up/down conversion, design trade-offs: rate, bandwidth, power and error probability, coding and decoding (block codes, convolutional coding and Viterbi decoding). Prerequisites: 179 or 261, and 178 or 278

Grading Basis

ROP - Letter or Credit/No Credit

Units Min	Units Max	Course Component	Enrollment Optional?
3	3	Lecture	No

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	3

Does this course satisfy the University Language Requirement?

No

EE282 - Computer Systems Architecture

Course Description

Course focuses on how to build modern computing systems, namely notebooks, smartphones, and data centers, covering primarily their hardware architecture and certain system software aspects. For each system class, we cover the system architecture, processor technology, advanced memory hierarchy and I/O organization, power and energy management, and reliability. We will also cover topics such as interactions with system software, virtualization, solid state storage, and security. The programming assignments allow students to explore performance/energy tradeoffs when using heterogeneous hardware resources on smartphone devices. Prerequisite: EE180. Recommended: CS 140.

Cross Listed Courses	Grading Basis
CS282 COMPUTER SYSTEMS ARCHITECTURE	ROP - Letter or Credit/No Credit

Units Min	Units Max	Course Component	Enrollment Optional?
3	3	Lecture	No

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	3

Does this course satisfy the University Language Requirement?

No

EE284 - Introduction to Computer Networks

Course Description

Structure and components of computer networks; functions and services; packet switching; layered architectures; OSI reference model; physical layer; data link layer; error control; window flow control; media access control protocols used in local area networks (Ethernet, Token Ring, FDDI) and satellite networks; network layer (datagram service, virtual circuit service, routing, congestion control, Internet Protocol); transport layer (UDP, TCP); application layer.

Grading Basis

ROP - Letter or Credit/No Credit

Units Min	Units Max	Course Component	Enrollment Optional?
3	3	Lecture	No

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	3

Does this course satisfy the University Language Requirement?

No

EE284A - Introduction to Internet of Things

Course Description

Internet of Things (IoT) origin, vision and definition. Application domains, use case scenarios and value propositions. Functional blocks of IoT systems: devices, communications, services, management, security, and application. Architectural reference model and design methodology. IoT Devices: sensors, actuators and embedded systems. Communications aspects of IoT systems: Internet infrastructure; wireless local area networks; radio access networks; wireless personal area networks; wireless sensor networks; wireless communication in vehicular environments; 5G. Current IoT frameworks and underlying architectures. Data storage and analytics. Web services. IoT system management tools. Security aspects of IoT systems. Open issues.

Grading Basis

ROP - Letter or Credit/No Credit

Units

Min	Max	Course Component	Enrollment Optional?
3	3	Lecture	No

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	3

Does this course satisfy the University Language Requirement?

No

EE285 - Embedded Systems Workshop

Course Description

Project-centric building hardware and software for embedded computing systems. This year the course projects are on a large interactive light sculpture to be installed in Packard. Syllabus topics will be determined by the needs of the enrolled students and projects. Examples of topics include: interrupts and concurrent programming, mechanical control, state-based programming models, signaling and frequency response, mechanical design, power budgets, software, firmware, and PCB design. Interested students can help lead community workshops to begin building the installation. Prerequisites: one of CS107, EE101A, EE108, ME80.

Cross Listed Courses	Grading Basis
CS241 EMBEDDED SYSTEMS WORKSHOP	ROP - Letter or Credit/No Credit

Units

Min	Max	Course Component	Enrollment Optional?
3	3	Lecture	No

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
Yes	9

Does this course satisfy the University Language Requirement?

No

EE290A - Curricular Practical Training for Electrical Engineers

Course Description

For EE majors who need work experience as part of their program of study. Final report required. Prerequisites: for 290B, EE MS and PhD students who have received a Satisfactory ("S") grade in EE290A; for 290C, EE PhD degree candidacy and an "S" grade in EE 290B; for 290D, EE PhD degree candidacy, an "S" grade in EE 290C and instructor consent.

Grading Basis

RSN - Satisfactory/No Credit

Units

Min	Max	Course Component	Enrollment Optional?
1	1	Individual Study	No

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	1

Does this course satisfy the University Language Requirement?

No

EE290B - Curricular Practical Training for Electrical Engineers

Course Description

For EE majors who need work experience as part of their program of study. Final report required. Prerequisites: for 290B, EE MS and PhD students who have received a Satisfactory ("S") grade in EE290A; for 290C, EE PhD degree candidacy and an "S" grade in EE 290B; for 290D, EE PhD degree candidacy, an "S" grade in EE 290C and instructor consent.

Grading Basis

RSN - Satisfactory/No Credit

Units

Min	Max	Course Component	Enrollment Optional?
1	1	Individual Study	No

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	1

Does this course satisfy the University Language Requirement?

No

EE290C - Curricular Practical Training for Electrical Engineers

Course Description

For EE majors who need work experience as part of their program of study. Final report required. Prerequisites: for 290B, EE MS and PhD students who have received a Satisfactory ("S") grade in EE290A; for 290C, EE PhD degree candidacy and an "S" grade in EE 290B; for 290D, EE PhD degree candidacy, an "S" grade in EE 290C and instructor consent.

Grading Basis

RSN - Satisfactory/No Credit

Units

Min	Max	Course Component	Enrollment Optional?
1	1	Individual Study	No

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	1

Does this course satisfy the University Language Requirement?

No

EE290D - Curricular Practical Training for Electrical Engineers

Course Description

For EE majors who need work experience as part of their program of study. Final report required. Prerequisites: for 290B, EE MS and PhD students who have received a Satisfactory ("S") grade in EE290A; for 290C, EE PhD degree candidacy and an "S" grade in EE 290B; for 290D, EE PhD degree candidacy, an "S" grade in EE 290C and instructor consent.

Grading Basis

RSN - Satisfactory/No Credit

Units

Min	Max	Course Component	Enrollment Optional?
1	1	Individual Study	No

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	1

Does this course satisfy the University Language Requirement?

No

EE290E - Curricular Practical Training for Electrical Engineers

Course Description

For EE majors who need work experience as part of their program of study. Final report required. Prerequisites: for 290B, EE MS and PhD students who have received a Satisfactory ("S") grade in EE290A; for 290C, EE PhD degree candidacy and an "S" grade in EE 290B; for 290D, EE PhD degree candidacy, an "S" grade in EE 290C and instructor consent; for 290E, EE PhD degree candidacy, an "S" grade in EE 290D and instructor consent.

Grading Basis

RSN - Satisfactory/No Credit

Units

Min	Max	Course Component	Enrollment Optional?
1	1	Individual Study	No

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	1

Does this course satisfy the University Language Requirement?

No

EE290F - Curricular Practical Training for Electrical Engineers

Course Description

For EE majors who need work experience as part of their program of study. Final report required. Prerequisites: EE PhD degree candidacy, an "S" grade in EE 290E and instructor consent.

Grading Basis

RSN - Satisfactory/No Credit

Units

Min	Max	Course Component	Enrollment Optional?
1	1	Individual Study	No

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	1

Does this course satisfy the University Language Requirement?

No

EE290G - Curricular Practical Training for Electrical Engineers

Course Description

For EE majors who need work experience as part of their program of study. Final report required. Prerequisites: EE PhD degree candidacy, an "S" grade in EE 290F and instructor consent.

Grading Basis

RSN - Satisfactory/No Credit

Units

Min	Max
1	1

Course Component	Enrollment Optional?
Individual Study	No

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	1

Does this course satisfy the University Language Requirement?

No

EE290H - Curricular Practical Training for Electrical Engineers

Course Description

For EE majors who need work experience as part of their program of study. Final report required. Prerequisites: EE PhD degree candidacy, an "S" grade in EE 290G and instructor consent.

Grading Basis

RSN - Satisfactory/No Credit

Units

Min	Max
1	1

Course Component	Enrollment Optional?
Individual Study	No

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	1

Does this course satisfy the University Language Requirement?

No

EE292A - Electronic Design Automation (EDA) and Machine Learning Hardware

Course Description

The class teaches cutting-edge optimization and analysis algorithms for the design of complex digital integrated circuits and their use in designing machine learning hardware. It provides working knowledge of the key technologies in Electronic Design Automation (EDA), focusing on synthesis, placement and routing algorithms that perform the major transformations between levels of abstraction and get a design ready to be fabricated. As an example, the design of a convolutional neural network (CNN) for basic image recognition illustrates the interaction between hardware and software for machine learning. It will be implemented on a state-of-the-art FPGA board. Prerequisite: EE 108.

Grading Basis

ROP - Letter or Credit/No Credit

Units

Min	Max
3	3

Course Component	Enrollment Optional?
Lab Section	Yes
Lecture	No

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	3

Does this course satisfy the University Language Requirement?

No

EE292C - Chemical Vapor Deposition and Epitaxy for Integrated Circuits and Nanostructures

Course Description

Fundamental aspects of CVD are initially considered, first focusing on processes occurring in the gas phase and then on those occurring on the surface. Qualitative understanding is emphasized, with minimal use of equations. Adding energy both thermally and by using a plasma is discussed; atomic-layer deposition is briefly considered. Examples of CVD equipment are examined. The second portion of the tutorial examines layers deposited by CVD. The focus is on group IV semiconductors especially epitaxial and heteroepitaxial deposition, in which the crystal structure of the depositing layer is related to that of the substrate. Polycrystalline silicon and the IC interconnect system are then discussed. Finally, the use of high-density plasmas for rapid gap filling is contrasted with alternative CVD dielectric deposition processes.

Grading Basis

RSN - Satisfactory/No Credit

Units

Min	Max
1	1

Course Component	Enrollment Optional?
Lecture	No

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	1

Does this course satisfy the University Language Requirement?

No

EE292D - Machine Learning on Embedded Systems

Course Description

This is a project-based class where students will learn how to develop machine learning models for execution in resource constrained environments such as embedded systems. In this class students will learn about techniques to optimize machine learning models and deploy them on a device such as a Arduino, Raspberry PI, Jetson, or Edge TPUs. The class has a significant project component. Prerequisites: CS 107(required), CS 229 (recommended), CS 230 (recommended).

Cross Listed Courses

CS329E EMBEDDED SYSTEMS

Grading Basis

RLT - Letter (ABCD/NP)

Units

Min	Max
3	3

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	3

Course Component	Enrollment Optional?
Lab Section	Yes
Lecture	No

Does this course satisfy the University Language Requirement?

No

EE292E - Seminar Series for Image Systems Engineering

Course Description

Seminar. For engineering students interested in camera and display engineering, computer vision, and computational imaging. Speakers include Stanford faculty and research scientists as well as industry professionals, mostly from consumer electronics companies. This course is open to graduate and professional students only, or with instructor consent.

Grading Basis

RSN - Satisfactory/No Credit

Units

Min	Max
1	1

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
Yes	99

Course Component	Enrollment Optional?
Seminar	No

Simple Requisites

EE 292E Prerequisite

Type

Prerequisite

EE 292E Prerequisite

This course is open to graduate and professional students only, or with instructor consent.

Additional Comments:

Does this course satisfy the University Language Requirement?

No

EE292F - Image Processing of Fine Art

Course Description

This course presents the application of rigorous digital image processing to problems in visualization and understanding of fine paintings, drawings, and other two-dimensional artworks. It builds upon a wealth of techniques but modifies and applies them to cases of interest to the technical art community. Such techniques include transforms such as DCT and wavelets, color quantization, blind source (image) separation, edge detection, super-resolution, visual style learning and transfer, digital in-painting, color transforms, level-set analysis, estimation of region statistics, Affine image transforms, and many others. Students will perform several projects which will involve coding, mathematical/statistical analysis, and explaining the relevance of the work to art scholarship.

Grading Basis

ROP - Letter or Credit/No Credit

Units

Min	Max	Course Component	Enrollment Optional?
3	3	Lecture	No

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	3

EE292H - Engineering, Entrepreneurship & Climate Change

Course Description

The purpose of this seminar series course is to help students and professionals develop the tools to apply the engineering and entrepreneurial mindset to problems that stem from climate change, in order to consider and evaluate possible stabilizing, remedial and adaptive approaches. This course is not a crash course on climate change or policy. Instead we will focus on learning about and discussing the climate problems that seem most tractable to these approaches. Each week Dr. Field and/or a guest speaker will lead a short warm-up discussion/activity and then deliver a talk in his/her area of expertise. We will wrap up with small-group and full-class discussions of related challenges/opportunities and possible engineering-oriented solutions. Class members are asked to do background reading before each class, to submit a question before each lecture, and to do in-class brainstorming. May be repeated for credit.

Grading Basis

RSN - Satisfactory/No Credit

Units

Min	Max	Course Component	Enrollment Optional?
1	1	Seminar	No

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
Yes	999

Does this course satisfy the University Language Requirement?

No

EE292I - Insanely Great Products: How do they get built?

Course Description

Great products are crafted by product teams, commonly composed of engineering, product management, and customer support. We start by identifying unmet market needs and then satisfying those needs through an iterative process of building from functional infancy to market leadership. In this class, we seek to demystify this process through direct conversations with guests who've delivered immensely successful products. We aim to introduce how great hardware and software products are crafted -- in both startups and larger companies. Students will learn why pursuing areas of interest and curiosity is critical to building world-class solutions to problems. Previous companies profiled: Apple, HP, Microsoft, VMWare, Genentech, Blue Bottle Coffee, Pixar, and Pivotal Labs -- to name a few. Previous guests include Ted Hoff (Inventor of the microprocessor and employee #12 at Intel), Diane Greene (Co-founder and CEO of VMware, former President of Google Cloud, and former Chair of The MIT Corporation), Rob Mee (Co-Founder of Pivotal Labs and Founder of Mechanical Orchard), Evans Hankey (former VP of Design at Apple), Matt Kraning (EE292i Alumnus, Co-Founder Expanse, acquired by Palo Alto Networks where Matt now serves as CTO Cortex), and Jon Rubinstein (NeXT, Apple, Palm). Pre-requisites: None

Grading Basis

RSN - Satisfactory/No Credit

Units

Min	Max	Course Component	Enrollment Optional?
1	1	Seminar	No

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	1

EE292J - Designing for Authenticity

Course Description

The Internet is at an inflection point. As mis/disinformation abounds and AI and synthetic media explode, the world's digital knowledge faces unprecedented threats. At the same time, a new generation of web technologies known as "Web3" offer new opportunities to protect the security and integrity of data. Our class jumps into this high-stakes moment and equips students with a new framework to understand and deploy methods to restore trust in digital content whether it's news and information, legally admissible evidence, or tamper-proof archives. Open to students of all experience levels, this class will provide an introduction to how advances in cryptography and the decentralized web can allow users to establish the provenance and veracity of data as it moves online. Students will create end-to-end technical prototypes and emerge with a new understanding that authenticity isn't a guaranteed part of information systems. You have to design for authenticity.

Grading Basis

ROP - Letter or Credit/No Credit

Units

Min	Max	Course Component	Enrollment Optional?
3	3	Lecture	No

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	3

No Requirements

EE292K - Insanely Great Products: Building YOU!

Course Description

This course introduces the set of skills and philosophies (beyond technical expertise) that will help students become world-class product professionals early in their careers. The legendary guests from EE292i mastered many such capabilities, ultimately yielding historic successes. While there are no guarantees of such historic accomplishment, we understand well many of the skills and practices required to "build" world-class professionals. Doing so dramatically increases your probability of success. Topics include: Identifying great job opportunities, interviewing to win; cultivating empathy -- strengthening teamwork, understanding customer needs, and captivating others with your vision; negotiating for yourself, your team, and your ideas; integrity -- why honesty, integrity, and decency remain the "coins of the realm" in the product world; why iteration always beats perfection; embracing failure to learn; recognizing your strengths and passions -- how to "double down" on strengths and leverage teammates to compensate for weaknesses; identifying emerging technical and business opportunities; building the emotional and physical stamina required for success in product development; learning how to maximize your economic outcomes; and much more. Prerequisites: None.

Grading Basis

RSN - Satisfactory/No Credit

Units

Min	Max	Course Component	Enrollment Optional?
1	1	Seminar	No

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	1

No Requirements

EE292S - Understanding the Sensors in your Smartphone

Course Description

This course provides an introduction to the sensor systems found in modern-day smartphones, wearables, and hearable devices. As much as we take their functionality for granted, there is a tremendous amount of engineering needed to sense "real world" signals such as acceleration, touch, or altitude. There will be an overview on the actual circuitry and hardware used in sensor implementations, with a focus on MEMS devices (eg, accelerometer/gyro), going up through the algorithms commonly seen in sensors processing, and finally fusion of data from multiple sensors to yield final data presented to a user. The four broad areas that will be covered are: Inertial sensing/movement; Touch sensing/authentication; Health sensing (PPG, ECG, SpO2); Next-generation (force, radar/ranging, ultrasonics, and more). There is a lab/project associated with each of these areas, each project spanning roughly two weeks. The projects are designed to be more at a system level; the student will be required to explore the performance and limitations of sensing hardware, and then take that understanding to solve real-world sensor problems. All projects will be built on a Raspberry Pi with various sensor boards; students should be comfortable with wiring up a small breadboard, and coding on an RPi a high-level language such as Python or Java. Prerequisites: EE101A, EE102A, and CS106A or equivalents.

Grading Basis

ROP - Letter or Credit/No Credit

Units

Min	Max	Course Component	Enrollment Optional?
3	3	Lecture	No

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	3

No Requirements

EE292T - SmartGrids and Advanced Power Systems Seminar

Course Description

A series of seminar and lectures focused on power engineering. Renowned researchers from universities and national labs will deliver bi-weekly seminars on the state of the art of power system engineering. Seminar topics may include: power system analysis and simulation, control and stability, new market mechanisms, computation challenges and solutions, detection and estimation, and the role of communications in the grid. The instructors will cover relevant background materials in the in-between weeks. The seminars are planned to continue throughout the next academic year, so the course may be repeated for credit.

Cross Listed Courses	Grading Basis
CEE272T SMARTGRIDS AND ADVANCED POWER	RSN - Satisfactory/No Credit

Units

Min	Max
1	2

Course Component	Enrollment Optional?
Seminar	No

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
Yes	4

Does this course satisfy the University Language Requirement?

No

EE292Y - Software Techniques for Emerging Hardware Platforms

Course Description

Research seminar on software techniques for emerging computational substrates with guest lectures from hardware designers from research and industry. This seminar explores the benefits of novel hardware technologies, the challenges gating broad adoption of these technologies, and how software techniques can help mitigate these challenges and improve the usability of these hardware platforms. Note that the computational substrates discussed vary depending on the semester. Topics covered include: In-memory computing platforms, dynamical system-solving mixed-signal devices, exible and bendable electronics, neuromorphic computers, intermittent computing platforms, ReRAMs, DNA-based storage, and optical computing platforms. Prerequisites: CS107 or CS107E (required) and EE180 (recommended).

Cross Listed Courses	Grading Basis
CS349H EMERGING HARDWARE PLATFORMS	ROP - Letter or Credit/No Credit

Units

Min	Max
3	3

Course Component	Enrollment Optional?
Lecture	No

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	3

Does this course satisfy the University Language Requirement?

No

EE293B - Fundamentals of Energy Processes

Course Description

For seniors and graduate students. Covers scientific and engineering fundamentals of renewable energy processes involving heat. Thermodynamics, heat engines, solar thermal, geothermal, biomass. Recommended: MATH 19-21; PHYSICS 41, 43, 45

Cross Listed Courses	Grading Basis
ENERGY201B FUNDAMENTALS OF ENERGY PROCESS	ROP - Letter or Credit/No Credit

Units

Min	Max
3	3

Course Component	Enrollment Optional?
Discussion	Yes
Lecture	No

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	3

EE300 - Master's Thesis and Thesis Research

Course Description

Independent work under the direction of a department faculty. Written thesis required for final letter grade. The continuing grade 'N' is given in quarters prior to thesis submission. See 390 if a letter grade is not appropriate. Course may be repeated for credit.

Grading Basis

RLT - Letter (ABCD/NP)

Units

Min	Max
1	15

Course Component	Enrollment Optional?
Individual Study	No

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
Yes	999

Does this course satisfy the University Language Requirement?

No

EE301 - Introductory Research Seminar in Electrical Engineering

Course Description

The EE 301 seminar course is offered primarily for incoming EE PhD students; however, all graduate or undergraduate students may enroll, and all students and faculty in the Department are welcome to attend. EE faculty members present seminars on their research, giving new PhD students an overview of research opportunities across the Department.

Grading Basis

RSN - Satisfactory/No Credit

Units

Min	Max
1	1

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
Yes	4

Course Component	Enrollment Optional?
Discussion	Yes
Seminar	No

Does this course satisfy the University Language Requirement?

No

EE303 - Autonomous Implantable Systems

Course Description

Integrating electronics with sensing, stimulation, and locomotion capabilities into the body will allow us to restore or enhance physiological functions. In order to be able to insert these electronics into the body, energy source is a major obstacle. This course focuses on the analysis and design of wirelessly powered catheter-deliverable electronics. Emphases will be on the interaction between human and electromagnetic fields in order to transfer power to the embedded electronics via electromagnetic fields, power harvesting circuitry, electrical-tissue interface, and sensing and actuating frontend designs.

Grading Basis

RLT - Letter (ABCD/NP)

Units

Min	Max
3	3

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	3

Course Component	Enrollment Optional?
Lecture	No

EE308 - Advanced Circuit Techniques

Course Description

Design of advanced analog circuits at the system level, including switching power converters, amplitude-stabilized and frequency-stabilized oscillators, voltage references and regulators, power amplifiers and buffers, sample-and-hold circuits, and application-specific op-amp compensation. Approaches for finding creative design solutions to problems with difficult specifications and hard requirements. Emphasis on feedback circuit techniques, design-oriented thinking, and hands-on experience with modern analog building blocks. Several designs will be built and evaluated, along with associated laboratory projects. Prerequisite: EE 251 or EE 314A.

Grading Basis

RLT - Letter (ABCD/NP)

Units

Min	Max
3	3

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	3

Course Component	Enrollment Optional?
Lecture	No

Does this course satisfy the University Language Requirement?

No

EE309A - Semiconductor Memory Devices and Circuit Design

Course Description

The functionality and performance of ULSI systems are increasingly dependent upon the characteristics of the memory subsystem. This course introduces students to various semiconductor memory devices: SRAM, DRAM and FLASH, that are used in today's memory subsystems. The course will cover various aspects of semiconductor memories, including basic operation principles, device design considerations, device scaling, device fabrication, memory array architecture, and addressing and readout circuits. The course will also introduce students to recent research in near- and in-memory computing using these memory technologies. The next course is this series is EE 309B, which talks about emerging non-volatile memory devices and circuit design. Pre-requisite: EE 216. Preferred: EE 316.

Grading Basis

ROP - Letter or Credit/No Credit

Units

Min	Max
3	3

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	3

Course Component	Enrollment Optional?
Lecture	No

Does this course satisfy the University Language Requirement?

No

EE309B - Emerging Non-Volatile Memory Devices and Circuit Design

Course Description

The functionality and performance of ULSI systems are increasingly dependent upon the characteristics of the memory subsystem. This course starts off where EE 309A leaves, and introduces students to various emerging non-volatile memory devices: metal oxide resistive switching memory (RRAM), nanoconductive bridge memory (CBRAM), phase change memory (PCM), magnetic tunnel junction memory, spin-transfer-torque random access memory (MRAM, STT-RAM), ferroelectric memory (FRAM) and ferroelectric transistor (FeFET). For each of these memories, the course will cover basic operation principles, device design considerations, device scaling, device fabrication, memory array architecture, and addressing and readout circuits. The course will also introduce students to recent in-memory computing research using these memory technologies. Pre-requisite: EE 216. Preferred: EE 316, EE 309A.

Grading Basis

ROP - Letter or Credit/No Credit

Units

Min	Max	Course Component	Enrollment Optional?
3	3	Lecture	No

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	3

Does this course satisfy the University Language Requirement?

No

EE310 - SystemX: Ubiquitous Sensing, Computing and Communication Seminar

Course Description

This is a seminar course with invited speakers. Sponsored by Stanford's SystemX Alliance, the talks will cover emerging topics in contemporary hardware/software systems design. Special focus will be given to the key building blocks of sensors, processing elements and wired/wireless communications, as well as their foundations in semiconductor technology, SoC construction, and physical assembly as informed by the SystemX Focus Areas. The seminar will draw upon distinguished engineering speakers from both industry and academia who are involved at all levels of the technology stack and the applications that are now becoming possible. May be repeat for credit

Grading Basis

RSN - Satisfactory/No Credit

Units

Min	Max	Course Component	Enrollment Optional?
1	1	Seminar	No

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
Yes	999

Does this course satisfy the University Language Requirement?

No

EE311 - Advanced Integrated Circuits Technology

Course Description

What are the practical and fundamental limits to the evolution of the technology of modern MOS devices and interconnects? How are modern devices and circuits fabricated and what future changes are likely? Advanced techniques and models of MOS devices and back-end (interconnect and contact) processing. What are future device structures and materials to maintain progress in integrated electronics? MOS front-end and back-end process integration. Prerequisites: EE 216 or equivalent. Recommended: EE 212.

Grading Basis

ROP - Letter or Credit/No Credit

Units

Min	Max	Course Component	Enrollment Optional?
3	3	Lecture	No

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	3

Does this course satisfy the University Language Requirement?

No

EE312 - Integrated Circuit Fabrication Laboratory

Course Description

Formerly EE 410. Fabrication, simulation, and testing of a submicron CMOS process. Practical aspects of IC fabrication including silicon wafer cleaning, photolithography, etching, oxidation, diffusion, ion implantation, chemical vapor deposition, physical sputtering, and electrical testing. Students also simulate the CMOS process using process simulator TSUPREM4 of the structures and electrical parameters that should result from the process flow. Taught in the Stanford Nanofabrication Facility (SNF). Preference to students pursuing doctoral research program requiring SNF facilities. Enrollment limited to 20. Prerequisites: EE 212, EE 216, or consent of instructor.

Grading Basis

RLT - Letter (ABCD/NP)

Units

Min	Max	Course Component	Enrollment Optional?
3	4	Laboratory	No

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	4

Does this course satisfy the University Language Requirement?

No

EE314A - RF Integrated Circuit Design

Course Description

Design of RF integrated circuits for communications systems, primarily in CMOS. Topics: the design of matching networks and low-noise amplifiers at RF, mixers, modulators, and demodulators; review of classical control concepts necessary for oscillator design including PLLs and PLL-based frequency synthesizers. Design of low phase noise oscillators. Design of high-efficiency (e.g., class E, F) RF power amplifiers, coupling networks. Behavior and modeling of passive and active components at RF. Narrowband and broadband amplifiers; noise and distortion measures and mitigation methods. Overview of transceiver architectures. Prerequisite: EE214B.

Grading Basis

RLT - Letter (ABCD/NP)

Units

Min	Max	Course Component	Enrollment Optional?
3	3	Lecture	No

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	3

Does this course satisfy the University Language Requirement?

No

EE315 - Analog-Digital Interface Circuits

Course Description

Analysis and design of circuits and circuit architectures for signal conditioning and data conversion. Fundamental circuit elements such as operational transconductance amplifiers, active filters, sampling circuits, switched capacitor stages and voltage comparators. Sensor interfaces for micro-electromechanical and biomedical applications. Nyquist and oversampling A/D and D/A converters. Prerequisite: EE 214B.

Grading Basis

RLT - Letter (ABCD/NP)

Units

Min	Max	Course Component	Enrollment Optional?
3	3	Lecture	No

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	3

Does this course satisfy the University Language Requirement?

No

EE316 - Advanced VLSI Devices

Course Description

In modern VLSI technologies, device electrical characteristics are sensitive to structural details and therefore to fabrication techniques. How are advanced VLSI devices designed and what future changes are likely? What are the implications for device electrical performance caused by fabrication techniques? Physical models for nanometer scale structures, control of electrical characteristics (threshold voltage, short channel effects, ballistic transport) in small structures, and alternative device structures for VLSI. Prerequisites: 216 or equivalent. Recommended: EE 212.

Grading Basis

RLT - Letter (ABCD/NP)

Units

Min	Max	Course Component	Enrollment Optional?
3	3	Lecture	No

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	3

Does this course satisfy the University Language Requirement?

No

EE317 - Special Topics on Wide Bandgap Materials and Devices

Course Description

Wide-bandgap (WBG) semiconductors present a pathway to push the limits of efficiency in optoelectronics and electronics enabling significant energy savings, offering new and compact architecture, and more functionality. We will first study the examples set by GaN and SiC in lighting, radiofrequency and power applications, then use it to explore new materials like Ga_2O_3, AlN and diamond to understand their potential to drive the future semiconductor industry. The term papers will include a short project that may require simulation to conduct device design and analysis. Prerequisites: EE 216 or EE 218

Grading Basis

RLT - Letter (ABCD/NP)

Units

Min	Max	Course Component	Enrollment Optional?
3	3	Lecture	No

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	3

Does this course satisfy the University Language Requirement?

No

EE323 - Energy in Electronics

Course Description

EE 323 examines energy in modern nanoelectronics, from fundamentals to systems. Fundamental topics include energy storage and transfer via electrons and phonons, ballistic limits of current and heat, meso- to macroscale mobility and thermal conductivity. Applied topics include power in nanoscale devices (1D nanotubes and nanowires, 2D materials, 3D silicon CMOS, resistive memory and interconnects), circuit leakage, temperature measurements, thermoelectric energy conversion, and thermal challenges in densely integrated systems. Basic knowledge of semiconductors, transistors, and Matlab (or similar) are recommended.

Grading Basis

RLT - Letter (ABCD/NP)

Units

Min	Max	Course Component	Enrollment Optional?
3	3	Lecture	No

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	3

EE329 - The Electronic Structure of Surfaces and Interfaces

Course Description

Physical concepts and phenomena for surface science techniques probing the electronic and chemical structure of surfaces, interfaces and nanomaterials. Microscopic and atomic models of microstructures; applications including semiconductor device technology, catalysis and energy. Physical processes of UV and X-ray photoemission spectroscopy, Auger electron spectroscopy, surface EXAFS, low energy electron diffraction, electron/photon stimulated ion desorption, scanning tunneling spectroscopy, ion scattering, energy loss spectroscopy and related imaging methods; and experimental aspects of these surface science techniques. Prerequisites: PHYSICS 70 and MATSCI 199/209, or consent of instructor.

Cross Listed Courses	Grading Basis
PHOTON329 ELECTRONIC STRUCTURE SURFACE	ROP - Letter or Credit/No Credit

Units

Min	Max	Course Component	Enrollment Optional?
3	3	Lecture	No

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	3

Does this course satisfy the University Language Requirement?

No

EE332 - Laser Dynamics

Course Description

Dynamic and transient effects in lasers including spiking, Q-switching, mode locking, frequency modulation, frequency and spatial mode competition, linear and nonlinear pulse propagation, pulse shaping. Formerly EE 232. Prerequisite: 236C.

Grading Basis

ROP - Letter or Credit/No Credit

Units

Min	Max	Course Component	Enrollment Optional?
3	3	Lecture	No

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	3

EE334 - Micro and Nano Optical Device Design

Course Description

Lecture and project course on design and analysis of optical devices with emphasis on opportunities and challenges created by scaling to the micrometer and nanometer ranges. The emphasis is on fundamentals, combined with some coverage of practical implementations. Prerequisite: EE 242 or equivalent

Grading Basis

ROP - Letter or Credit/No Credit

Units

Min	Max	Course Component	Enrollment Optional?
3	3	Lecture	No

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	3

EE336 - Nanophotonics

Course Description

Recent developments in micro- and nanophotonic materials and devices. Basic concepts of photonic crystals. Integrated photonic circuits. Photonic crystal fibers. Superprism effects. Optical properties of metallic nanostructures. Sub-wavelength phenomena and plasmonic excitations. Meta-materials. Prerequisite: Electromagnetic theory at the level of 242.

Cross Listed Courses

MATSCI346 NANOPHOTONICS

Grading Basis

ROP - Letter or Credit/No Credit

Units

Min	Max
3	3

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	3

Course Component	Enrollment Optional?
Lecture	No

Does this course satisfy the University Language Requirement?

No

EE340 - Quantum Photonics

Course Description

Introduction to quantum photonics - generation and manipulation of quantum light on a chip. Classical (coherent) and quantum (Fock, squeezed, entangled, cluster) states of light. Cavity quantum electrodynamics: strong and weak-coupling regime (Purcell factor, spontaneous emission control). Light-matter entanglement in solid state. Measurements of photon statistics and photon indistinguishability; quantum state tomography. Platforms for quantum photonics. Quantum networks; photonics in quantum simulation and computing. Prerequisites: undergraduate/ introductory graduate electromagnetics and quantum mechanics

Grading Basis

ROP - Letter or Credit/No Credit

Units

Min	Max
3	3

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	3

Course Component	Enrollment Optional?
Lecture	No

Does this course satisfy the University Language Requirement?

No

EE346 - Introduction to Nonlinear Optics

Course Description

Wave propagation in anisotropic, nonlinear, and time-varying media. Microscopic and macroscopic description of electric-dipole susceptibilities. Free and forced waves; phase matching; slowly varying envelope approximation; dispersion, diffraction, space-time analogy. Harmonic generation; frequency conversion; parametric amplification and oscillation; electro-optic light modulation. Raman and Brillouin scattering; nonlinear processes in optical fibers. Prerequisites: 242, 236C.

Grading Basis

RLT - Letter (ABCD/NP)

Units

Min	Max
3	3

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	3

Course Component	Enrollment Optional?
Discussion	Yes
Lecture	No

Does this course satisfy the University Language Requirement?

No

EE347 - Optical Methods in Engineering Science

Course Description

Design and understanding of modern optical systems. Topics: geometrical optics; aberration theory; systems layout; applications such as microscopes, telescopes, optical processors. Computer ray tracing program as a design tool. Prerequisite: 236A or equivalent.

Grading Basis

ROP - Letter or Credit/No Credit

Units

Min	Max
3	3

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	3

Course Component	Enrollment Optional?
Lecture	No

EE348 - Advanced Optical Fiber Communications

Course Description

Optical amplifiers: gain, saturation, noise. Semiconductor amplifiers. Erbium-doped fiber amplifiers. System applications: preamplified receiver performance, amplifier chains. Raman amplifiers, lumped vs. distributed amplification. Group-velocity dispersion management: dispersion-compensating fibers, filters, gratings. Interaction of dispersion and nonlinearity, dispersion maps. Multichannel systems. Wavelength-division multiplexing components: filters, multiplexers. WDM systems, crosstalk. Time, subcarrier, code and polarization-division multiplexing. Comparison of modulation techniques: differential phase-shift keying, phase-shift keying, quadrature-amplitude modulation. Comparison of detection techniques: noncoherent, differentially coherent, coherent. Prerequisite: 247.

Grading Basis

ROP - Letter or Credit/No Credit

Units

Min	Max	Course Component	Enrollment Optional?
3	3	Lecture	No

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	3

EE355 - Imaging Radar and Applications

Course Description

Radar remote sensing, radar image characteristics, viewing geometry, range coding, synthetic aperture processing, correlation, range migration, range/Doppler algorithms, wave domain algorithms, polar algorithm, polarimetric processing, interferometric measurements. Applications: surfafe deformation, polarimetry and target discrimination, topographic mapping surface displacements, velocities of ice fields. Prerequisites: EE261. Recommended: EE254, EE278, EE279.

Cross Listed Courses

GEOPHYS265 IMAGING RADAR + APPLICATIONS

Grading Basis

ROP - Letter or Credit/No Credit

Units

Min	Max	Course Component	Enrollment Optional?
3	3	Lecture	No

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	3

EE356A - Resonant Converters

Course Description

Miniaturization of efficient power converters remain a challenge in power electronics whose goal is improving energy use and reducing waste. In this course, we will study the design of Resonant converters which are capable of operating at higher frequencies than their 'hard-switch' counterparts. Resonant converter are found in high performance applications where high control bandwidth and high power density are required. We will also explore practical design issues and trade off in selecting converter topologies in high performance applications. Prerequisites: EE153/EE253.

Grading Basis

RLT - Letter (ABCD/NP)

Units

Min	Max	Course Component	Enrollment Optional?
3	3	Lecture	No

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	3

Does this course satisfy the University Language Requirement?

No

EE356B - Magnetics Design in Power Electronics

Course Description

Inductors and transformers are ubiquitous components in any power electronics system. They are components that offer great design flexibility, provide electrical isolation and can reduce semiconductor stresses, but they often dominate the size and cost of a power converter and are notoriously difficult to miniaturize. In this class we will discuss the design and modeling of magnetic components, which are essential tasks in the development of high performance converters and study advanced applications. Prerequisites: EE153/EE253.

Grading Basis

RLT - Letter (ABCD/NP)

Units

Min	Max	Course Component	Enrollment Optional?
3	3	Lecture	No

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	3

Does this course satisfy the University Language Requirement?

No

EE358 - Wireless System Design

Course Description

Wireless systems are commonly used in our day-to-day life. Different applications impose different design trade-offs and optimizations. This course will cover various building blocks (filters, channel coding, MIMO algorithms, carrier/timing recovery, and preamble design) of a complete wireless system and their respective design trade-offs. Students will implement these building blocks in Simulink and softwaredefined radio to enhance their understandings. The course will also cover various wireless standards, RF chain and analog-digital co-design, digital implementation platforms, and DSP arithmetic. Prerequisites: One of EE 279, EE 359, EE 379, or equivalent.

Grading Basis

RLT - Letter (ABCD/NP)

Units

Min	Max
3	3

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	3

Course Component	Enrollment Optional?
Lab Section	Yes
Lecture	No

Does this course satisfy the University Language Requirement?

No

EE359 - Wireless Communications

Course Description

This course will cover advanced topics in wireless communications as well as current wireless system design. Topics include: an overview of current and future wireless systems; wireless channel models including path loss, shadowing, and statistical multipath channel models; fundamental capacity limits of wireless channels; digital modulation and its performance in fading and under intersymbol interference; techniques to combat fading including adaptive modulation and diversity; multiple antenna (MIMO) techniques to increase capacity and diversity, intersymbol interference including equalization, multicarrier modulation (OFDM), and spread spectrum; and multiuser system design, including multiple access techniques. Course is 3 units but can be taken for 4 units with an optional term project. Prerequisite: 279 or instructor consent.

Grading Basis

ROP - Letter or Credit/No Credit

Units

Min	Max
3	4

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	4

Course Component	Enrollment Optional?
Lecture	No

Does this course satisfy the University Language Requirement?

No

EE364A - Convex Optimization I

Course Description

Convex sets, functions, and optimization problems. The basics of convex analysis and theory of convex programming: optimality conditions, duality theory, theorems of alternative, and applications. Least-squares, linear and quadratic programs, semidefinite programming, and geometric programming. Numerical algorithms for smooth and equality constrained problems; interior-point methods for inequality constrained problems. Applications to signal processing, communications, control, analog and digital circuit design, computational geometry, statistics, machine learning, and mechanical engineering. Prerequisite: linear algebra such as EE263, basic probability.

Cross Listed Courses

CME364A CONVEX OPTIMIZATION I

Grading Basis

ROP - Letter or Credit/No Credit

Units

Min	Max
3	3

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	3

Course Component	Enrollment Optional?
Lecture	No

Does this course satisfy the University Language Requirement?

No

EE364B - Convex Optimization II

Course Description

Continuation of 364A. Subgradient, cutting-plane, and ellipsoid methods. Decentralized convex optimization via primal and dual decomposition. Monotone operators and proximal methods; alternating direction method of multipliers. Exploiting problem structure in implementation. Convex relaxations of hard problems. Global optimization via branch and bound. Robust and stochastic optimization. Applications in areas such as control, circuit design, signal processing, and communications. Course requirements include project. Prerequisite: 364A.

Cross Listed Courses

CME364B CONVEX OPTIMIZATION II

Grading Basis

ROP - Letter or Credit/No Credit

Units

Min	Max
3	3

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	3

Course Component	Enrollment Optional?
Lecture	No

Does this course satisfy the University Language Requirement?

No

EE364M - Mathematics of Convexity

Course Description

This course covers the elegant mathematical underpinnings of convex optimization, with a focus on those analytic techniques central to the successes of the field. Topics include, but are not limited to, convex sets and functions, separation theorems, duality, set-valued analysis, and the mathematical insights central to the development of modern optimization methods. Pre- or co-requisite: EE364A, and mathematical analysis at the level of MATH171.

Grading Basis

ROP - Letter or Credit/No Credit

Units

Min	Max	Course Component	Enrollment Optional?
1	1	Lecture	No

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	1

No Requirements

EE367 - Computational Imaging

Course Description

Digital photography and basic image processing, convolutional neural networks for image processing, denoising, deconvolution, single pixel imaging, inverse problems in imaging, proximal gradient methods, introduction to wave optics, time-of-flight imaging, end-to-end optimization of optics and imaging processing. Emphasis is on applied image processing and solving inverse problems using classic algorithms, formal optimization, and modern artificial intelligence techniques. Students learn to apply material by implementing and investigating image processing algorithms in Python. Term project. Recommended: EE261, EE263, EE278.

Cross Listed Courses

CS448I COMPUTATIONAL IMAGING

Grading Basis

ROP - Letter or Credit/No Credit

Units

Min	Max	Course Component	Enrollment Optional?
3	3	Lecture	No

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	3

Does this course satisfy the University Language Requirement?

No

EE369A - Medical Imaging Systems I

Course Description

Imaging internal structures within the body using high-energy radiation and ultrasound, studied from a systems viewpoint. Modalities covered: x-ray, computed tomography, nuclear medicine, and ultrasound. Analysis of existing and proposed systems in terms of resolution, frequency response, detection sensitivity, noise, and potential for improved diagnosis. Pre- or corequisite: EE 261 or equivalent.

Cross Listed Courses

BMP269A MEDICAL IMAGING SYSTEMS 1

Grading Basis

ROP - Letter or Credit/No Credit

Units

Min	Max	Course Component	Enrollment Optional?
3	3	Lecture	No

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	3

EE369B - Medical Imaging Systems II

Course Description

Imaging internal structures within the body using magnetic resonance studied from a systems viewpoint. Analysis of magnetic resonance imaging systems including physics, Fourier properties of image formation, effects of system imperfections, image contrast, and noise. Pre- or corequisite: EE 261 or equivalent

Cross Listed Courses

BMP269B MEDICAL IMAGING SYSTEMS II

Grading Basis

ROP - Letter or Credit/No Credit

Units

Min	Max	Course Component	Enrollment Optional?
3	3	Lecture	No

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	3

Does this course satisfy the University Language Requirement?

No

EE369C - Medical Image Reconstruction

Course Description

Reconstruction problems from medical imaging, including magnetic resonance imaging (MRI), computed tomography (CT), and positron emission tomography (PET). Problems include reconstruction from non-uniform frequency domain data, automatic deblurring, phase unwrapping, reconstruction from incomplete data, and reconstruction from projections. Prerequisite: 369B.

Grading Basis

RLT - Letter (ABCD/NP)

Units

Min	Max	Course Component	Enrollment Optional?
3	3	Lecture	No

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	3

EE370 - Reinforcement Learning: Behaviors and Applications

Course Description

This course treats reinforcement learning, which addresses the design of agents to operate in environments where actions induce delayed consequences. Concepts generalize those arising in bandit learning, which is covered in EE277/MS&E 237A. The course covers principled and scalable approaches to realizing a range of intelligent learning behaviors. Topics include planning, credit assignment, and learning of models, value functions, and policies. Motivating examples will be drawn from generative artificial intelligence, web services, control, and finance. Prerequisites: EE277.

Cross Listed Courses	Grading Basis
MS&E237B REINFORCEMENT LEARNING	ROP - Letter or Credit/No Credit

Units

Min	Max	Course Component	Enrollment Optional?
3	3	Lecture	No

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	3

No Requirements

EE372 - Design Projects in VLSI Systems II

Course Description

This is a follow on course to EE272. While in EE272 you learn the EDA tool flow and design a pre-specified digital neural network accelerator and an analog block, in EE372 you will leverage your knowledge from EE272 and design and fabricate your own digital/analog/mixed-signal chip. This is a completely project-based course where, working in teams, you will propose your own mixed-signal chip, write a Verilog or a synthesizable C++ model of your chip, create a testing/debug strategy for your chip, wrap custom layout to fit into a standard cell system, use synthesis and place and route tools to create the layout of your chip, perform physical verification of your chip and finally tape it out. Useful for anyone who will build a chip in their Ph.D. Pre-requisites: EE271, EE272 and experience in digital/analog circuit design.

Grading Basis

ROP - Letter or Credit/No Credit

Units

Min	Max	Course Component	Enrollment Optional?
3	5	Lecture	No

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	5

Does this course satisfy the University Language Requirement?

No

EE374 - Blockchain Foundations

Course Description

A detailed exploration of the foundations of blockchains, What blockchains are, how they work, and why they are secure. Transactions, blocks, chains, proof-of-work and stake, wallets, the UTXO model, accounts model, light clients. Throughout the course, students build their own nodes from scratch. Security is defined and rigorously proved. The course is heavy on both engineering and theory. This course is a deeper investigation into the consensus layer of blockchains while CS 251 is a broader investigation, and it can be taken with or without having taken CS 251. Prerequisites: CS106 or equivalent, significant programming experience; CS103 or equivalent; CS109 or EE178 or equivalent.

Grading Basis

ROP - Letter or Credit/No Credit

Units

Min	Max	Course Component	Enrollment Optional?
3	3	Lecture	No

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	3

Does this course satisfy the University Language Requirement?

No

EE376C - Universal Information Processing

Course Description

Universal schemes for information processing tasks such as compression, communication, sequential probability assignments, prediction, denoising, and filtering. Characterization of performance limits in stochastic, semi-stochastic, and individual sequence settings. Ziv-Lempel compression as an end goal, and as an engine for other information processing tasks. Trade Offs between performance (e.g. accuracy), amounts of data processed, and computation. Prerequisites: EE276, EE278 or equivalent, or instructor's permission.

Grading Basis

ROP - Letter or Credit/No Credit

Units

Min	Max	Course Component	Enrollment Optional?
3	3	Lecture	No

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	3

EE377 - Information Theory and Statistics

Course Description

Information theoretic techniques in probability and statistics. Fano, Assouad,and Le Cam methods for optimality guarantees in estimation. Large deviationsand concentration inequalities (Sanov's theorem, hypothesis testing, theentropy method, concentration of measure). Approximation of (Bayes) optimalprocedures, surrogate risks, f-divergences. Penalized estimators and minimumdescription length. Online game playing, gambling, no-regret learning. Prerequisites: EE 276 (or equivalent) or STATS 300A.

Cross Listed Courses	Grading Basis
STATS311 INFORMATION THEORY AND STATS	ROP - Letter or Credit/No Credit

Units

Min	Max	Course Component	Enrollment Optional?
3	3	Lecture	No

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	3

Does this course satisfy the University Language Requirement?

No

EE378A - Statistical Signal Processing

Course Description

Basic concepts of statistical decision theory; Bayes decision theory; HMMs and their state estimation (Forward--backward), Kalman as special case, approximate state estimation (particle filtering, Extended Kalman Filter), unknown parameters; Inference under logarithmic loss, mutual information as a fundamental measure of statistical relevance, properties of mutual information: data processing, chain rules. Directed information. Prediction under logarithmic loss; Context Tree Weighting algorithm; Sequential decision making in general: prediction under general loss functions, causal estimation, estimation of directed information. Non-sequential inference via sequential probability assignments. Universal denoising; Denoising from a decision theoretic perspective: nonparametric function estimation, wavelet shrinkage, density estimation; Estimation of mutual information on large alphabets with applications such as boosting the Chow-Liu algorithm. Estimation of the total variation distance, estimate the fundamental limit is easier than to achieve the fundamental limit; Peetre's K-functional and bias analysis: bias correction using jackknife, bootstrap, and Taylor series; Nonparametric functional estimation. Prerequisites: Familiarity with probability theory and linear algebra at the undergraduate level.

Grading Basis

ROP - Letter or Credit/No Credit

Units

Min	Max	Course Component	Enrollment Optional?
3	3	Lecture	No

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	3

Does this course satisfy the University Language Requirement?

No

EE379 - Digital Communication

Course Description

Modulation: linear, differential and orthogonal methods; signal spaces; power spectra; bandwidth requirements. Detection: maximum likelihood and maximum a posteriori probability principles; sufficient statistics; correlation and matched-filter receivers; coherent, differentially coherent and noncoherent methods; error probabilities; comparison of modulation and detection methods. Intersymbol interference: single-carrier channel model; Nyquist requirement; whitened matched filter; maximum likelihood sequence detection; Viterbi algorithm; linear equalization; decision-feedback equalization. Multi-carrier modulation: orthogonal frequency-division multiplexing; capacity of parallel Gaussian channels; comparison of single- and multi-carrier techniques. Prerequisite: EE102B and EE278 (or equivalents). EE279 is helpful but not required.

Grading Basis

ROP - Letter or Credit/No Credit

Units

Min	Max	Course Component	Enrollment Optional?
3	3	Lecture	No

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	3

EE379A - Data Transmission Design

Course Description

Data Transmission Design is the first of a two-quarter sequence (leading to EE379B) in MSEE communications depth sequence. Intended students are those interested in research or design of data transmission systems' lower layers. The course includes methods for transmission designs with and without coding and includes basic examples as well as their relationship to modern current/next-generation wireless and wireline transmission systems. The course also develops and uses information measures as generalizations of signal processing and minimum-mean-square-error estimation, developing design intution. Basic phase-locking and synchronization methods also appear. EE379B progresses to multidimensional modulation methods and their use in modern and next-generation multiuser MIMO networks, along with network-design strategies. Prerequisites: EE102B and EE278 (or equivalents). EE279 is helpful but not required.

Grading Basis

ROP - Letter or Credit/No Credit

Units

Min	Max	Course Component	Enrollment Optional?
3	3	Lecture	No

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	3

No Requirements

EE379B - Advanced Data Transmission Design

Course Description

EE 379B follows 379A and focuses on state-of-the-art data communication system theory and design, particularly systems with multiple users and dimensions (MIMO over parallel antennas or wires). The focus is on multi-user physical-layer channels like multiple access, broadcast, and interference channels, their capacity regions and designs to achieve any points therein. Examples include the latest cellular, Wi-Fi, wireline, cable, and other systems that stress fundamental transmission limits. Topics include system design, particularly physical-layer modulation/coding analysis and optimization through various artificial intelligence and optimization methods for multi-dimensional channels. Included are methods to design and adapt both transmitter and receiver to variable channels. Prerequisites: EE 278, linear algebra, EE 279 or EE 379A (or 379), or instructor consent. Instructor: Cioffi

Grading Basis

ROP - Letter or Credit/No Credit

Units

Min	Max	Course Component	Enrollment Optional?
3	3	Lecture	No

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	3

No Requirements

EE380 - Colloquium on Computer Systems

Course Description

Live presentations of current research in the design, implementation, analysis, and applications of computer systems. Topics range over a wide range and are different every quarter. Topics may include fundamental science, mathematics, cryptography, device physics, integrated circuits, computer architecture, programming, programming languages, optimization, applications, simulation, graphics, social implications, venture capital, patent and copyright law, networks, computer security, and other topics of related to computer systems. May be repeated for credit.

Grading Basis

RSN - Satisfactory/No Credit

Units

Min	Max	Course Component	Enrollment Optional?
1	1	Colloquium	No

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
Yes	999

Does this course satisfy the University Language Requirement?

No

EE381 - Sensorimotor Learning for Embodied Agents

Course Description

This is an advanced course that will focus on modern machine learning algorithms for autonomous robots as an embodied intelligent agent. It covers advanced topics that center around 1. what is embodied AI and how it differs from internet AI, 2. how embodied agents perceive their environment from raw sensory data and make decisions, and 3. continually adapt to the physical world through both hardware and software improvements. By the end of the course, we hope to prepare you for conducting research in this area, knowing how to formulate the problem, design the algorithm, critically validate the idea through experimental designs and finally clearly present and communicate the findings. Students are expected to read, present, and debate the latest research papers on embodied AI, as well as obtain hands-on experience through the course projects. Prerequisites: Recommended EE 160A/EE 260A /CS 237A or equivalent.

Cross Listed Courses

CS381 SENSORIMOTOR LEARNING

Grading Basis

ROP - Letter or Credit/No Credit

Units

Min	Max	Course Component	Enrollment Optional?
3	3	Lecture	No

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	3

No Requirements

EE382A - Parallel Processors Beyond Multicore Processing

Course Description

Formerly EE392Q. The current parallel computing research emphasizes multi-cores, but there are alterna-tive array processors with significant potential. This hands-on course focuses on SIMD (Single-Instruction, Multiple-Data) massively parallel processors. Topics: Flynn's Taxonomy, parallel architectures, Kestrel architecture and simulator, principles of SIMD programming, parallel sorting with sorting networks, string comparison with dynamic programming (edit distance, Smith-Waterman), arbitrary-precision operations with fixed-point numbers, reductions, vector and matrix multiplication, image processing algo-rithms, asynchronous algorithms on SIMD ("SIMD Phase Programming Model"), Man-delbrot set, analysis of parallel performance.

Grading Basis

RLT - Letter (ABCD/NP)

Units Min	Units Max	Course Component	Enrollment Optional?
3	3	Lecture	No

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	3

Does this course satisfy the University Language Requirement?

No

EE382C - Interconnection Networks

Course Description

The architecture and design of interconnection networks used to communicate from processor to memory, from processor to processor, and in switches and routers. Topics: network topology, routing methods, flow control, router microarchitecture, and performance analysis. Enrollment limited to 30. Prerequisite: 282.

Grading Basis

ROP - Letter or Credit/No Credit

Units Min	Units Max	Course Component	Enrollment Optional?
3	3	Lecture	No

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	3

Does this course satisfy the University Language Requirement?

No

EE384A - Internet Switching and Routing Protocols

Course Description

Protocol standards developed by the IEEE 802.1 committee for Layer 2 Bridging (Switching) in Local Area Networks (LANs), Metropolitan Area Networks (MANs), and Data Center (DC) networks, providing enhanced services such as expedited traffic capabilities, dynamic use of multicast addresses, virtual LANs (VLANs), carrier-grade Metro-Ethernet, congestion control in data center networks (DC-TCP), and Time Sensitive Networking (TSN). Protocol standards developed by the Internet Engineering Task Force (IETF) for Layer 3 addressing and routing in the Internet: IPv4 addressing and Network Address Translation (NAT), Interior Gateway Protocols (RIP and OSPF), Exterior Gateway Protocol (BGP-4), Multi-Protocol Label Switching (MPLS), Multicast Routing, Mobile IP (MIP), and routing in Mobile Ad Hoc Networks (MANET) with application in Wi-Fi Mesh Networks standardized by IEEE 802.11. Prerequisite: EE 284 or CS 144.

Grading Basis

ROP - Letter or Credit/No Credit

Units Min	Units Max	Course Component	Enrollment Optional?
3	3	Lecture	No

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	3

Does this course satisfy the University Language Requirement?

No

EE384S - Performance Engineering of Computer Systems & Networks

Course Description

Modeling and control methodologies for high-performance network engineering, including: Markov chains and stochastic modeling, queueing networks and congestion management, dynamic programming and task/processor scheduling, network dimensioning and optimization, and simulation methods. Applications for design of high-performance architectures for wireline/wireless networks and the Internet, including: traffic modeling, admission and congestion control, quality of service support, power control in wireless networks, packet scheduling in switches, video streaming over wireless links, and virus/worm propagation dynamics and countermeasures. Enrollment limited to 30. Prerequisites: basic networking technologies and probability.

Grading Basis

ROP - Letter or Credit/No Credit

Units Min	Units Max	Course Component	Enrollment Optional?
3	3	Lecture	No

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	3

Does this course satisfy the University Language Requirement?

No

EE387 - Algebraic Error Correcting Codes

Course Description

Introduction to the theory of error correcting codes, emphasizing algebraic constructions, and diverse applications throughout computer science and engineering. Topics include basic bounds on error correcting codes; Reed-Solomon and Reed-Muller codes; list-decoding, list-recovery and locality. Applications may include communication, storage, complexity theory, pseudorandomness, cryptography, streaming algorithms, group testing, and compressed sensing. Prerequisites: Linear algebra, basic probability (at the level of, say, CS109, CME106 or EE178) and "mathematical maturity" (students will be asked to write proofs). Familiarity with finite fields will be helpful but not required.

Cross Listed Courses	Grading Basis
CS250 ALGEBRAIC ERROR CORRECTING COD	ROP - Letter or Credit/No Credit

Units

Min	Max	Course Component	Enrollment Optional?
3	3	Lecture	No

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	3

Does this course satisfy the University Language Requirement?

No

EE390 - Special Studies or Projects in Electrical Engineering

Course Description

Independent work under the direction of a faculty member. Individual or team activities may involve lab experimentation, design of devices or systems, or directed reading. May be repeated for credit.

Grading Basis

RSN - Satisfactory/No Credit

Units

Min	Max	Course Component	Enrollment Optional?
1	15	Individual Study	No

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
Yes	999

Does this course satisfy the University Language Requirement?

No

EE391 - Special Studies and Reports in Electrical Engineering

Course Description

Independent work under the direction of a faculty member; written report or written examination required. Letter grade given on the basis of the report; if not appropriate, student should enroll in 390. May be repeated for credit.

Grading Basis

RLT - Letter (ABCD/NP)

Units

Min	Max	Course Component	Enrollment Optional?
1	15	Individual Study	No

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
Yes	999

Does this course satisfy the University Language Requirement?

No

EE392AA - Multi-User Data Transmission

Course Description

EE 392AA focuses on state-of-the-art data communication system theory and design, particularly systems with multiple users and dimensions (MIMO over parallel antennas or wires). The focus is on multi-user physical-layer channels like multiple access, broadcast, and interference channels, their capacity regions and designs to achieve any points therein. Examples include the latest cellular, Wi-Fi, wireline, cable, and other systems that stress fundamental transmission limits. Topics include system design, particularly physical-layer modulation/coding analysis and optimization through various artificial intelligence optimization methods for multi-dimensional channels. Included are methods to design and adapt both transmitter and receiver to variable channels. Prerequisites: EE 278, linear algebra, EE 279 or EE 379, or instructor consent.

Grading Basis

ROP - Letter or Credit/No Credit

Units

Min	Max	Course Component	Enrollment Optional?
3	3	Lecture	No

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	3

EE392B - Industrial AI

Course Description

The seminar features guest lectures from the industry. The Industrial AI (I-AI) computing applications are at the center of on-going digital transformation. Known as the Fourth Industrial Revolution, or Industry 4.0, this is a multi-trillion-dollar transformation of economy. The I-AI is related to Internet of Things (IoT), where 'things' include man-made systems and business processes: industrial, transportation, operations and support, and supply chains. I-AI applications are mission critical with large cost of error compared to AI apps for the Internet of People. The lecturers from technology (e.g., computing) companies, consultancies, AI vendors, OEMs, and end users of the I-AI will discuss business and 'big picture' technical issues. Example vertical industries are energy, transportation, oil and gas, data centers, and manufacturing.

Grading Basis

RSN - Satisfactory/No Credit

Units Min	Units Max	Course Component	Enrollment Optional?
1	1	Seminar	No

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
Yes	999

EE392D - Wireless Sensing Systems

Course Description

This research course will cover current topics related to wireless communication, sensing, and the Internet of Things (IoT). Students will read published research papers, participate in group discussions, and complete a final research project in small groups. The course is open to all Ph.D., masters, and advanced undergraduate students. Prerequisites: This course does not have any official prerequisites. However, students should have a mature understanding of wireless sensor networks and embedded systems.

Grading Basis

ROP - Letter or Credit/No Credit

Units Min	Units Max	Course Component	Enrollment Optional?
3	3	Lecture	No

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	3

No Requirements

EE392F - Large-Scale Convex Optimization: Algorithms and Analyses via Monotone Operators

Course Description

This course presents a unified analysis of large-scale convex optimization algorithms through the abstraction of monotone operators. The topics include monotone operators, primal-dual methods, randomized coordinate update methods, ADMM-type methods, maximality, duality, acceleration, scaled relative graphs, and distributed and decentralized optimization

Grading Basis

ROP - Letter or Credit/No Credit

Units Min	Units Max	Course Component	Enrollment Optional?
3	3	Lecture	No

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	3

No Requirements

EE400 - Thesis and Thesis Research

Course Description

Limited to candidates for the degree of Engineer or Ph.D.May be repeated for credit.

Grading Basis

RSN - Satisfactory/No Credit

Units Min	Units Max	Course Component	Enrollment Optional?
1	15	Thesis/Dissertation	No

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
Yes	999

Does this course satisfy the University Language Requirement?

No

EE402A - Topics in International Technology Management

Course Description

Theme for Autumn 2024, "Innovations in supply chains and manufacturing in Asia: Opportunities and challenges in realignment." Distinguished speakers and panels from industry and the public sector address topics such as post-Covid regional redistribution of international supply chains in Asia; new technology solutions for manufacturing resilience and industry-level geopolitical security; digital integration of manufacturing, supply chain, and business data; related new trends in key industries such as semiconductors, electronics, and automotive; and the broader impact of these developments on US-Asia business.

Cross Listed Courses

EASTASN402A TOPICS INT'L TECH MANAGEMENT, EALC402A TOPICS INT'L TECH MANAGEMENT

Grading Basis

RSN - Satisfactory/No Credit

Units

Min	Max
1	1

Course Component	Enrollment Optional?
Lecture	No

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
Yes	999

Does this course satisfy the University Language Requirement?

No

EE402T - Entrepreneurship in Asian High Tech Industries

Course Description

Distinctive patterns and challenges of entrepreneurship in Asia; update of business and technology issues in the creation and growth of start-up companies in major Asian economies. Distinguished speakers from industry, government, and academia.

Cross Listed Courses

EALC402T ENTREPRENEURSHIP IN ASIA, EASTASN402T ENTREPRENEURSHIP IN ASIA

Grading Basis

RSN - Satisfactory/No Credit

Units

Min	Max
1	1

Course Component	Enrollment Optional?
Lecture	No

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
Yes	999

Does this course satisfy the University Language Requirement?

No

EE42 - Introduction to Electromagnetics and Its Applications

Course Description

Electricity and magnetism and its essential role in modern electrical engineering devices and systems, such as sensors, displays, DVD players, and optical communication systems. The topics that will be covered include electrostatics, magnetostatics, Maxwell's equations, one-dimensional wave equation, electromagnetic waves, transmission lines, and one-dimensional resonators. Pre-requisites: none.

Cross Listed Courses

ENGR42 INTRO ENGINEERING ELECTROMAGNE

Grading Basis

RLT - Letter (ABCD/NP)

Units

Min	Max
5	5

Course Component	Enrollment Optional?
Laboratory	No
Lab Section	Yes

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	5

This course has been approved for the following WAYS

Applied Quantitative Reasoning (AQR), Scientific Method and Analysis (SMA)

Does this course satisfy the University Language Requirement?

No

EE469B - RF Pulse Design for Magnetic Resonance Imaging

Course Description

Magnetic resonance imaging (MRI) and spectroscopy (MRS) based on the use of radio frequency pulses to manipulate magnetization. Analysis and design of major types of RF pulses in one and multiple dimensions, analysis and design of sequences of RF pulses for fast imaging, and use of RF pulses for the creation of image contrast in MRI. Prerequisite: 369B.

Grading Basis

ROP - Letter or Credit/No Credit

Units

Min	Max
3	3

Course Component	Enrollment Optional?
Lecture	No

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	3

EE60N - Man versus Nature: Coping with Disasters Using Space Technology

Course Description

Preference to freshman. Natural hazards, earthquakes, volcanoes, floods, hurricanes, and fires, and how they affect people and society; great disasters such as asteroid impacts that periodically obliterate many species of life. Scientific issues, political and social consequences, costs of disaster mitigation, and how scientific knowledge affects policy. How spaceborne imaging technology makes it possible to respond quickly and mitigate consequences; how it is applied to natural disasters; and remote sensing data manipulation and analysis. GER:DB-EngrAppSci

Cross Listed Courses

GEOPHYS60N MAN VERSUS NATURE

Grading Basis

ROP - Letter or Credit/No Credit

Units

Min	Max
4	4

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	4

Course Component	Enrollment Optional?
SU Intro Seminar - Freshman	No

EE64 - Mechanical Prototyping for Electrical Engineers

Course Description

This course will give non-mechanical engineers experience designing mechanical assemblies specifically for manufacture with readily accessible tools such as 3D printers and laser cutters. It will also teach students to debug their own mechanical designs, and interface them with other components (such as store bought parts). By the end of the quarter students will feel comfortable independently designing and manufacturing simple assemblies to solve issues in their projects, careers and daily lives. The course will meet in Lab64 (Room 134) on the first floor of Packard. Class website: ee64.stanford.edu

Grading Basis

ROP - Letter or Credit/No Credit

Units

Min	Max
3	3

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	3

Course Component	Enrollment Optional?
Activity	No

EE65 - Modern Physics for Engineers

Course Description

This course introduces the core ideas of modern physics that enable applications ranging from solar energy and efficient lighting to the modern electronic and optical devices and nanotechnologies that sense, process, store, communicate and display all our information. Though the ideas have broad impact, the course is widely accessible to engineering and science students with only basic linear algebra and calculus through simple ordinary differential equations as mathematics background. Topics include the quantum mechanics of electrons and photons (Schr¿dinger's equation, atoms, electrons, energy levels and energy bands; absorption and emission of photons; quantum confinement in nanostructures), the statistical mechanics of particles (entropy, the Boltzmann factor, thermal distributions), the thermodynamics of light (thermal radiation, limits to light concentration, spontaneous and stimulated emission), and the physics of information (Maxwell's demon, reversibility, entropy and noise in physics and information theory). Pre-requisite: Physics 41. Pre- or co-requisite: Math 53 or CME 102.

Cross Listed Courses

ENGR65 MODERN PHYSICS FOR ENGINEERS

Grading Basis

RLT - Letter (ABCD/NP)

Units

Min	Max
4	4

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	4

Course Component	Enrollment Optional?
Lecture	No

This course has been approved for the following WAYS

Scientific Method and Analysis (SMA)

Does this course satisfy the University Language Requirement?

No

EE801 - TGR Project

Course Description

May be repeated for credit.

Grading Basis

RTG - TGR

Units

Min	Max
0	0

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
Yes	999

Course Component	Enrollment Optional?
Thesis/Dissertation	No

Does this course satisfy the University Language Requirement?

No

EE802 - TGR Dissertation

Course Description

May be repeated for credit.

Grading Basis

RTG - TGR

Units

Min	Max	Course Component	Enrollment Optional?
0	0	Thesis/Dissertation	No

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
Yes	999

Does this course satisfy the University Language Requirement?

No

EE84N - From the Internet for People to the Internet of Things

Course Description

Driven by the ubiquity of the Internet and advances in various technological fields, all aspects of the physical world in which we live are undergoing a major transformation. Underlying this transformation is a concept known as the Internet of Things (IoT) which envisions that every physical object in the world could be connected to the Internet. This concept is at the root of such developments as the fourth industrial revolution, precision agriculture, smart cities, intelligent transportation, home and building automation, precision medicine, etc. In this seminar, we trace back the origins of the IoT concept in terms of both the vision and pioneering work, identify the building blocks of an IoT system, and explore enabling technologies pertaining to the devices that get attached to things (possibly comprising sensors, actuators, and embedded systems) and the communications capabilities (RFID, Bluetooth, wireless sensor networks, Wi-Fi, Low Power WANs, cellular networks, vehicular communications). Students will apply the acquired knowledge to the design of IoT systems meeting specific objectives in various application domains.

Grading Basis

ROP - Letter or Credit/No Credit

Units

Min	Max	Course Component	Enrollment Optional?
3	3	SU Intro Seminar - Freshman	No

Course Repeatable for Degree Credit?	Total Units Allowed for Degree Credit
No	3

Does this course satisfy the University Language Requirement?

No