Electrical Engineering

Department of Electrical Engineering

School of Engineering and Applied Sciences
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Overview

Electrical engineering plays an integral role in our society, contributing to nearly everything we do in our everyday lives. For example, Electrical Engineers provide energy solutions to light our homes; develop biomedical devices and instrumentation to saves lives; use nanotechnology to produce better, faster, and stronger materials; facilitate social interactions via communications; provide multimedia entertainment with consumer electronics ; and advance new green technologies that will power our future while protecting the environment. Electrical engineers can be found in almost all sectors of the work force, including research and development, product design, manufacturing, operations, service, technical sales, marketing, consulting, and education.

The undergraduate degree offered by the department is the bachelors of science in electrical engineering (BSEE). The program provides the scope of knowledge and training needed for employment in the field and also forms the basis for further study at the graduate level. Students interested in computer architecture, software, and networking may also take courses offered by the Department of Computer Science and Engineering. These courses cover topics including computer networks, high-performance computing, and VLSI design.

Electrical Engineering Program Educational Objectives:
The recent graduate shall:

- Demonstrate expertise and career advancement in their field through the application of fundamental knowledge (mathematics and science), skills (problem solving), and engineering tools;
- Communicate effectively by contributing to conference presentations, journal publications, industrial and internal documents, patent applications, reports, and/or scholarly journal papers;
- Contribute to the achievement of their organization’s goals as an effective leader and/or effective team member; and
- Be engaged in their profession and life-long learning by using their knowledge and expertise to aid civic institutions, educational organizations, and professional societies.

The program is designed to serve both students who intend to enter industry directly and others who plan to continue their education through formal graduate study.

About our Degrees

The electrical engineering BS degree is accredited by the Accreditation Board for Engineering and Technology (ABET) and prepares students for graduate study and/or professional practice.

Acceptance Criteria - BS
See the School of Engineering and Applied Sciences for acceptance information.

Students can select EE as a major if they are students in good standing within the School of Engineering and Applied Sciences, or when they apply to UB. Non-engineering students seeking to change their major to EE should first apply to the School of Engineering and Applied Sciences.

Acceptance Information - BS/MBA

Must have good standing as an electrical engineering undergraduate student and be accepted as a graduate student by the School of Management.

Degree Requirements

Students must meet minimum GPA and residency requirements in engineering as specified by the Dean of Engineering to graduate from the program. See School of Engineering and Applied Sciences for additional academic requirements.
Electrical Engineering

Please see Degrees and Policies.

About our Courses

The BS curriculum includes math, science, and basic engineering courses in the freshman and sophomore years, required electrical engineering courses in the junior and senior years, and technical elective courses in the senior year. As there are many similarities during the first two years of all engineering disciplines' curricula, students can transfer among engineering majors fairly easily in the freshman and sophomore years. Students have considerable flexibility in the selection of technical elective courses, allowing them to specialize in an electrical engineering sub-discipline. Also available to interested students are several work-experience courses (internships and engineering co-op).

Suggested Introductory Courses

- EAS 140 Engineering Principles
- EAS 202 Engineering Impact on Society
- EE 101 Basic Electronics
- CHE 107 General Chemistry for Engineers
- EE 202 EE 203 Circuit Analysis I - II
- MTH 141 MTH 142 College Calculus I - II
- PHY 107-PHY 108 General Physics I - II

The typical class size for:

Freshman/introductory courses is: 100
Sophomore/intermediate courses is: 50-180
Upper level/advanced courses is: 10-50

In the Department of Electrical Engineering, what do teaching assistants (TAs) do?

Teaching Assistants (TAs) assist professors in all courses with laboratory and recitation sections. They frequently lead small-group discussion sections and may also assist with grading.

For course descriptions, please see Courses.

About our Faculty

Faculty Specializations

See http://www.ee.buffalo.edu/people/full_time.php for descriptions of the specializations of our faculty.

Our faculty have been awarded various honors from the university community, including Tau Beta Pi Teacher of the Year awards, Milton Plesur Excellence in Teaching Awards, the UB Teaching Innovation Award, UB Distinguished Professorships, UB's Exceptional Scholars Award for Sustained Achievement, and a Wilson Greatbatch Professorship for Advanced Power Sources. Several have been recognized with awards from the State University of New York (SUNY) system, such as SUNY Chancellor's Awards for Excellence in Teaching, the SUNY Research Foundation Award for Research and Scholarship, and SUNY Distinguished Professorships. In addition, there have been national and international recognition through National Science Foundation Career Awards, a National Medal of Technology, and Fellow recognition in several international technical societies, including the Institute of Electrical and Electronics Engineers, the Optics Society of America, and the American Association for the Advancement of Science.

The director of undergraduate studies, Pao-Lo Liu, can be reached at 716.645.1021 or paololiu@buffalo.edu.

Faculty Distinctions

Tau Beta Pi Teacher of the Year
Milton Plesur Excellence in Teaching Award
Chancellor's Award for Excellence in Teaching

See a list of our Undergraduate Faculty.

About our Facilities

Many electrical engineering courses take advantage of UB's technologically equipped classrooms. The department of electrical engineering
Electrical Engineering

provides its students with a computing laboratory equipped with state of the art software, as well as recently upgraded teaching laboratories for electronic circuit design and analysis. Ground-breaking for our new engineering building was in 2009, and ribbon-cutting for the Barbara and Jack Davis Hall is scheduled for 2011. Davis Hall includes a 5,000 square foot clean room with special vibration free facilities to enable nanotechnology research in addition to state of the art lecture hall and research laboratories.

Acceptance Information

For acceptance information please see the Undergraduate Catalog entry for the School of Engineering and Applied Sciences.

Transfer Policy

Transfer students must first apply to the university and meet the university transfer admission requirements before consideration for admission to the Department of Electrical Engineering. Electrical engineering courses completed at other colleges and offered as substitutes for UB courses are evaluated individually by the EE Undergraduate Curriculum Committee. A determination is made by an evaluation of the student's transcripts, course content, contact hours, and grades earned. Most courses taken from an ABET accredited college level electrical engineering department are acceptable. Evaluations for transfer credits of general education, basic science, and engineering science courses completed at other universities and colleges are done through the Office of Undergraduate Education, School of Engineering and Applied Sciences, 410 Bonner Hall. For more information, see School of Engineering and Applied Sciences.

Extracurricular Activities

- Institute of Electrical and Electronics Engineers (Student Chapter)
- IEEE Computer Society (Student Chapter)
- Robotics Club
- Eta Kappa Nu
- Tau Beta Pi

See the UB Student Association.

Practical Experience and Special Academic Opportunities

The electrical engineer is involved in a broad spectrum of challenging activities, such as research, development, product design, manufacturing, maintenance and service engineering, sales, energy, environmental concerns, and education. Electrical engineers design, develop, test, and supervise the manufacture of electrical and electronic systems. Electrical equipment includes power generating and transmission equipment used by electric utilities; electric motors; machinery controls; and lighting and control in buildings, automobiles, and aircrafts. Electronics involves semiconductors, computers, communications, consumer electronics, medical diagnosis, photonics, and nano science and technology.

Alumni in Electrical Engineering have found employment in the following fields:

- Circuit design
- Communications
- Consulting
- Education
- Electrical systems
- Environmental problem solving
- Maintenance
- Management
- Manufacturing
- Medical electronics and imaging
- Operation of technical systems
- Power engineering
- Product design
- Research and development
- Service
Technical sales and marketing

Salary Information

Beginning salaries: A bachelor's degree graduate average is $56,000. The 25-75% range is $56,000 - $64,350. Factors influencing salary: Skills, experience, internship, project and design experience, geographic location, and size of company. Educational level influence on salary: A master's degree graduate's average is $71,455 and 25-75% range is $64,000 - $80,000. The PhD graduate's average is $88,893 and the 25% - 75% range is $80,000 - $97,646.

What percentage of graduates goes on to graduate school?

25%

Formal system of tracking graduates?

The department does have a formal system for tracking graduates. Tracking is done by the School of Engineering & Applied Sciences Alumni Association.

What percentage of graduates goes on to find related employment?

100%

Degree Options

The Department of Electrical Engineering offers a BS degree in Electrical Engineering and a combined degree program that leads to two degrees: a BS in Electrical Engineering and a MBA in Business Administration.

Degrees Offered

Undergraduate: BS
Combined: BS/MBA
Graduate: MS, MEng, PhD

Links to Further Information About this Program

● Undergraduate Catalog
● Undergraduate Admissions
● Graduate Admissions
● Department of Electrical Engineering
● School of Engineering and Applied Sciences

Electrical Engineering - B.S.

Acceptance Criteria

See the School of Engineering and Applied Sciences Acceptance Information at http://undergrad-catalog.buffalo.edu/academicprograms/eas_degrees.shtml

Required Courses

CHE 107 General Chemistry for Engineers
CSE 379 Introduction to Microprocessors and Microcomputers
CSE 380 Introduction to Microprocessors Lab
EAS 140 Engineering Principles
EAS 202 Engineering Impact on Society
EAS 230 Engineering Computation
EAS 305 Applied Probability
EE 101 Basic Electronics or one technical elective
EE 202 Circuit Analysis
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- **EE 205** Signals and Systems
- **EE 278** Digital Principles
- **EE 310** Electronic Devices and Circuits I
- **EE 311** Electronic Devices and Circuits II
- **EE 324** Electromagnetic theory
- **EE 352** Introduction to Electronics Lab
- **EE 353** Electronic Circuits Lab
- **EE 383** Communication Systems
- **EE 408** Senior Seminar
- **EE 409** Senior Design Implementation
- **EE 436** Fundamentals of Energy Systems
- **MTH 141** College Calculus I
- **MTH 142** College Calculus II
- **MTH 241** College Calculus III
- **MTH 306** Introduction to Differential Equations
- **PHY 107** General Physics I
- **PHY 108** General Physics II
- **PHY 158** General Physics II Lab
- **PHY 207** General Physics III
- **PHY 257** General Physics III Lab
- Two restricted upper-division technical electives
- Three unrestricted upper-division technical electives
- One free elective

**Summary**

Total required credit hours for the major: 108

See [Baccalaureate Degree Requirements](#) for general education and remaining university requirements.

### Recommended Sequence of Program Requirements

**FIRST YEAR**
- **Fall:** CHE 107, EAS 140, MTH 141
- **Spring:** EE 101, MTH 142, PHY 107, EAS 202

**SECOND YEAR**
- **Fall:** EE 202, EE 278, MTH 306, PHY 108/PHY 158
- **Spring:** EAS 230, EE 205, MTH 241, PHY 207/PHY 257

**THIRD YEAR**
- **Fall:** EE 305, EE 310, EE 324, EE 352
- **Spring:** CSE 379, CSE 380, EE 311, EE 353, EE 383

**FOURTH YEAR**
- **Fall:** EE 408, EE 436, two technical electives, one free elective
- **Spring:** EE 409, three technical electives

### Electives and Course Groupings

*Electrical Engineering Requirements*

A total of five technical electives and one free elective are required.

At least two upper-division technical electives must be chosen from CSE courses; EE courses; **MAE 340** Systems Analysis; **MAE 443** Continuous Control Systems; or **MAE 444** Digital Control Systems.

Three of the upper-division technical electives are unrestricted.

For students entering prior to fall 2011 please refer to the undergraduate catalog from the year you entered the university.

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### Electrical Engineering/Business Administration - B.S / M.B.A

**Acceptance Criteria**

Good standing as an electrical engineering undergraduate student and acceptance as a graduate student by the School of Management.

**Advising Notes**

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Electrical Engineering

The internship may be taken the previous summer to lighten the load in the fifth year.

**Required Courses**

- CHE 107 General Chemistry for Engineers
- CSE 379 Introduction to Microprocessors and Microcomputers
- CSE 380 Introduction to Microprocessors Lab
- EAS 140 Engineering Principles
- EAS 202 Engineering Impact on Society
- EAS 230 Engineering Computation
- EAS 305 Applied Probability
- EE 101 Basic Electronics or one technical elective
- EE 202 Circuit Analysis
- EE 205 Signals and Systems
- EE 278 Digital Principles
- EE 310 Electronic Devices and Circuits I
- EE 311 Electronic Devices and Circuits II
- EE 324 Electromagnetic Theory
- EE 352 Introduction to Electronics Laboratory
- EE 353 Electronic Circuits Laboratory
- EE 383 Communication Systems
- EE 408 Senior Seminar
- EE 409 Senior Design Implementation
- EE 436 Fundamentals of Energy Systems
- MGA 604 Introduction to Financial Accounting
- MGA 609 Management Accounting
- MGB 601 Behavioral and Organizational Concepts for Management
- MGE 601 Economics for Managers
- MGF 631 Financial Management
- MGG 635 Business Communication
- MGM 625 Marketing Management
- MGO 630 Operations and Service Management
- MGO 641 Strategic Management
- MGT 601 Ethics & Corporate Finance
- MTH 141 College Calculus I
- MTH 142 College Calculus II
- MTH 241 College Calculus III
- MTH 306 Introduction to Differential Equations
- PHY 107 General Physics I
- PHY 108 General Physics II
- PHY 158 General Physics II Lab
- PHY 207 General Physics III
- PHY 257 General Physics III Lab
- Two electrical engineering technical electives
- Six MBA Electives
- MBA Practicum

**Summary**

Total required credits for the undergraduate portion: 95
Total required credits for the B.S./M.B.A.: 143

See [Baccalaureate Degree Requirements](#) for general education and remaining university requirements.

Refer to the School of Management’s MBA handbook for requirements for MBA candidates.

**Recommended Sequence of Program Requirements**

**FIRST YEAR**
- Fall: CHE 107, EAS 140, MTH 141
- Spring: EAS 202, EE 101, MTH 142, PHY 107

**SECOND YEAR**
- Fall: EE 202, EE 278, MTH 306, PHY 108, PHY 158
- Spring: EAS 230, EE 205, MTH 241, PHY 207/PHY 257

**THIRD YEAR**
- Fall: EAS 305, EE 310, EE 324, EE 352, EE 378
- Spring: CSE 379, CSE 380, EE 311, EE 353, EE 383
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FOURTH YEAR
Fall: EE 408, EE 436, MGA 604, MGB 601, MGT 601, MGF 631, one electrical engineering technical elective
Spring: EE 409, MGA 609, MGF 631, MGG 635, MGM 625, MGO 630, MGO 641

FIFTH YEAR
Fall: MGE 601, two MBA electives, MBA Practicum, one EE/CSE technical elective
Spring: four MBA electives

Contact the School of Management for flex core course and elective options.

Electives and Course Groupings

Electrical Engineering Technical Electives (minimum 6 credits)
A total of two technical electives are required. These upper-division technical electives must be chosen from CSE courses or EE courses. Contact the Department of Electrical Engineering for elective options.

A BS diploma and an MBA diploma are awarded upon completion, with a transcript notation that these degrees were awarded as part of a combined degree program.

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EE 101: Basic Electronics
Credits: 3
Semester(s): Spring
Type: LEC/LAB

Introductory electronics course for engineering and science majors. Emphasizes analog and digital electronic systems organization, data acquisition, and signal transmission. A laboratory once a week illustrates these techniques by specific circuit devices.

EE 200: Electrical Engineering Concepts/Non-Majors
Credits: 3
Pre-requisites: PHY 108 or PHY 118
Co-requisites: MTH 306
Type: LEC/REC

Introduces aspects of electrical engineering useful to all the engineering disciplines. Course material includes basic circuit analysis and networks, frequency response, elementary solid-state electronics, digital circuits, and energy conversion and transmission. Not intended for electrical or engineering physics majors. Students may not receive credit for this and EE 202.

EE 202: Circuit Analysis I
Credits: 4
Semester(s): Fall, Spring
Type: LEC/REC

Provides the foundation for understanding and analyzing linear circuits that include resistors, capacitors, inductors, and ideal operational amplifiers. Course coverage begins at the basic definitions of voltage, current and power and culminates with discussions on how to design an operational amplifier-based filter. Topics include: voltage and circuit, independent voltage and current sources, Kirchhoff's laws, parallel and series resistive circuits, equivalent subcircuits, loop and nodal analysis, dependent sources, ideal operational amplifiers, capacitor and inductor circuits, transient analysis of first-order and second-order circuits, phasor analysis of circuits, Laplace transform techniques and 's-domain' circuit analysis, frequency response, Bode plots, filters. Students will be expected to learn and use circuit simulation software, such as Multisim.

EE 203: Circuit Analysis II
Credits: 4
Semester(s): Fall, Spring
Pre-requisites: EE 202
Type: LEC/REC

A continuation of EE 202. Brief review of basic concepts of time-domain circuit analysis; phasor analysis of steady-state ac circuits; complex power and three-phase systems; Laplace transform techniques and 's-domain' circuit analysis; transfer function; linear circuit design. Selected problem assignments and a final design project require use of circuit analysis software tools.

EE 310: Electronic Devices and Circuits I
Credits: 3
Semester(s): Fall
Pre-requisites: EE 202, EE 310
Co-requisites: EE 312 or EE 352
Type: LEC/REC

Electronic devices, including operational amplifiers, diodes, bipolar junction transistors and field-effect transistors, the basic circuits in which these devices are used, and computer-aided circuit analysis for these devices and circuits.

EE 311: Electronic Devices and Circuits II
Electrical Engineering

Credits: 3  
Semester(s): Spring  
Type: LEC/LAB

Differential and multistage amplifiers with bipolar junction transistors (BJT) and field-effect transistors (FET). Biasing in integrated circuits and active loads. Frequency response of common-emitter (common-source), common-base (common-gate), common-collector (common-drain) single BJT (FET) stages. Frequency response of differential-pair, cascode, and multistage circuits. Selection of coupling and bypass capacitors. Analog integrated circuits. Metal-Oxide-Semiconductor (MOS) digital circuits with emphasis on CMOS.

EE 312: Basic Electronic Instrumentation Laboratory

Credits: 2  
Semester(s): Fall  
Pre-requisites: EE 202  
EE 312  
Co-requisites: EE 310  
Type: LEC/LAB

For computer engineering and other non-EE majors.

Trains students how to design, build, diagnose, and characterize electronic circuits. Topics include instrumentation, semiconductor devices, and electronic circuits. Covers both analog and digital circuits. Laboratory projects include filters, operational amplifiers, dc power supply, MOSFET amplifier, BJT amplifier, logic gates, timing, and counters.

EE 324: Applied Electromagnetics

Credits: 4  
Semester(s): Fall, Spring  
Pre-requisites: EE 202, MTH 241, PHY 108 or PHY 118  
Type: LEC/REC

Topics include vector calculus; electric fields; charge distributions; dielectrics, energy, forces in the presence of dielectrics; Laplace's and Poisson's equations; magnetostatics; Faraday's induction law; time-dependent phenomena; waves.

EE 342: Nanotechnology Engineering and Science Lab

Credits: 1  
Type: LAB

The laboratory course consists of ten modules with an experiment in each module. The modules cover basics of modern Nanoelectronics and Nanotechnology. A complete set of laboratory experiments delivers to students a hands-on experience in this field. Students use contemporary equipment to visualize and to characterize nano-world.

EE 352: Introduction to Electronics Lab

Credits: 3  
Semester(s): Fall  
Pre-requisites: EE 202  
EE 352  
Co-requisites: EE 310  
Type: LEC/LAB

Trains students how to design, build, diagnose, and characterize electronic circuits. Topics include instrumentation, semiconductor devices, and electronic circuits. Covers both analog and digital circuits. Laboratory projects include filters, operational amplifiers, diodes, dc power supply, ac power control, BJT amplifier, CMOS, logic gates, timing, and counters.

EE 353: Electronic Circuits Lab

Credits: 3  
Semester(s): Spring  
Type: LEC/LAB

An engineering design lab. Fifty-minute lecture and 230-minute lab per week. Involves analyzing and designing single and multistage electronic circuits using FETS, BJTs, and op amps. Asks students to design a variety of amplifiers to meet certain specifications. They practice SPICE and use their knowledge of analog circuits to complete the projects.

EE 401: RF and Microwave Circuits I

Credits: 3  
Semester(s): Fall  
Type: LEC

The first of a two-course sequence in the area of RF and microwave circuit design. Initial topics include transmission line equations, reflection coefficient, VSWR, return loss, and insertion loss. Examples include impedance matching networks using lumped elements, single-section and multi-section quarter wave transformers, single-stub and double-stub tuners, the design of directional couplers, and hybrids. There is a student design project for a planar transmission line circuit based upon the software package Microwave Office. The design is fabricated and tested.

EE 403: Introduction to Plasma Processing

Credits: 3  
Semester(s): Spring  
Pre-requisites: MTH 242 or MTH 306, PHY 108 or PHY 118  
Type: LEC

Introduces plasma processing including plasma deposition, plasma etching, gaseous electronics, gas lasers and plasma materials processing. Topics include basic atomic theory, elementary kinetic theory of gases, motion of charges in electric and magnetic fields, plasma properties, plasma generation and devices, plasma-surface interactions, electrodes and discharge characteristics, plasma diagnostics and plasma simulation. Students prepare web-based presentations in current plasma technologies with focus on applications in electrical engineering field.

EE 408: Senior Seminar

Credits: 1  
Semester(s): Fall  
Type: SEM

Covers the ethical, social, economic, and safety considerations in engineering practice essential for a successful engineering career.

EE 410: Electronic Instrument Design I
Electrical Engineering

EE 413: Communication Electronics
Credits: 4  
Semester(s): Fall  
Type: LEC/LAB  
Design of electronic instruments, with emphasis on the use of analog and digital integrated circuits. Topics include techniques for precise measurements; sensors and their use for measurement of temperature, displacement, light, and other physical quantities; active and passive signal conditioning; and power supplies. Individuals or groups design and demonstrate an instrument, and provide a written report.

EE 415: Microelectromechanical Systems
Credits: 3  
Semester(s): Fall  
Type: LEC  
Intended for first-year graduate students. Silicon-based integrated MEMS promise reliable performance, miniaturization and low-cost production of sensors and actuator systems with broad applications in data storage, biomedical systems, inertial navigation, micromanipulation, optical display and microfluid jet systems. The course covers such subjects as materials properties, fabrication techniques, basic structure mechanics, sensing and actuation principles, circuit and system issues, packaging, calibration, and testing.

EE 416: Signal Processing Algorithms
Credits: 3  
Semester(s): Spring  
Type: LEC/REC  
Signals and samples, the z-transform. The discrete Fourier transform. Frequency and time-domain response of filters. Digital filter design, FIR and IIR filters. Digital filter structures. Multirate filters and signals. Fast convolution and correlation algorithms. Interdisciplinary aspects: VLSI for DSP; SAW and CCD devices; computational aspects. Heavy design experience with signal processing software. Students are expected to complete several design studies and a final project in the areas of digital filter design and signal processing algorithms. Matlab or similar packages are to be used both in the design process as well as in verification of design objectives.

EE 418: Quantum Mechanics for Engineers
Credits: 3  
Pre-requisites: Senior standing  
Type: LEC  
Relation to classical mechanics, wave properties, Schrodinger equation, finite barrier potentials, tunneling, perturbation theory, nano-scale devices.

EE 419: Industrial Control Systems
Credits: 3  
Semester(s): Fall  
Type: LEC/REC  
An application-oriented course to introduce students to the basic principles and concepts employed in analysis and synthesis of modern-day analog and microcomputer control systems. Topics include: review of vectors, matrices, and Laplace transforms, followed by introduction to block diagram, signal flow graph, and state-variable representation of physical systems, network and linear graph techniques of system modeling; time-domain, frequency domain, and state-space analysis of linear control systems, control concepts in multivariable systems, hierarchy of control structures, design of analog and digital controllers.

EE 421: Semiconductor Materials
Credits: 3  
Semester(s): Fall  
Pre-requisites: EE 310  
Type: LEC  
Reviews semiconductor materials properties that are important for device operation. Also, discusses semiconductor devices along with important materials properties for each device. Reviews the device models employed in SPICE circuit simulations. Uses several SPICE simulation projects to learn about the SPICE device models and about the effect of materials properties on the device performance and circuit operation. Devices covered are: pn junction diode; SPICE pn junction diode models and model parameters; MOS field effect transistor, SPICE MOSFET models and model parameters; CMOS integrated circuits; bipolar transistor fundamentals; SPICE BJT models and model parameters; MS junction; mesfet; jfet; SPICE models; PSPICE or HSPICE simulations of semiconductor devices.

EE 422: Nanomaterials
Credits: 3  
Semester(s): Spring  
Type: LEC  
The recent emergence of fabrication tools and techniques capable of constructing nanometer-sized structures has opened up numerous possibilities for the development of new devices with size domains ranging from 0.1 - 50 nm. The course introduces basic single-charged electronics, including quantum dots and wires, single-electron transistors (SETs), nanoscale tunnel junctions, and so forth. Giant magnetoresistance (GMR) in multilayered structures are presented with their applications in hard disk heads, random access memory (RAM) and sensors. Discusses optical devices including semiconductor lasers incorporating active regions of quantum wells and self assembled formation of quantum-dot-structures for new generation of semiconductor layers. Finally, devices based on single- and multi-walled carbon nanotubes are presented with emphasis on their unique electronic and mechanical properties that are expected to lead to ground breaking industrial nanodevices. The course also includes discussions on such fabrication techniques as laser-ablation,
magnetron and ion beam sputter deposition, epitaxy for layer structures, rubber stamping for nanoscale wire-like patterns, and electroplating into nanoscale porous membranes.

EE 423: Nanotechnology & Science

Credits: 3
Pre-requisites: Senior standing
Co-requisites: EE 418
Type: LEC

EE 424: Introduction to Nanoelectronics, Nanostructure Physics, and Applications

Credits: 3
Semester(s): Fall
Type: LEC

Covers 2-D electron systems, quantum wires and dots, ballistic transport, quantum interference, and single-electron tunneling.

EE 425: Electrical Devices I

Credits: 4
Semester(s): Spring
Pre-requisites: EE 203 or EE 324
Type: LEC/LAB

Principles of electromagnetic energy conversion with applications to motors and generators. Topics include magnetic circuits, transformers, hysteresis, field energy, dc and ac motors. Students learn the basic fundamentals of electro-mechanical energy conversion. Design project with laboratory validation accounts for 50% of grade.

EE 428: Biomechanics and Lab-on-a-Chip

Credits: 3
Type: LEC

Covers various commonly used micro/nanofabrication techniques, microfluidics, various chemical and biochemical applications such as separation, implantable devices, drug delivery, and microsystems for cellular studies and tissue engineering. Discusses recent and future trends in BioMEMS and nanobiosensors. Students will gain a broad perspective in the area of micro/nano systems for biomedical and chemical applications.

EE 429: Introduction to Electromagnetic Compatibility

Credits: 3
Semester(s): Fall
Type: LEC

EMC deals with interference in electronic systems. For senior and first-year graduate students and industrial professionals who have an interest in designing electronic systems that comply with current commercial and military standards on EMC such as the FCC Part 15 and CISPR 22. Both specify limits on radiated and conducted emissions for digital devices which are defined as any electronic device that has digital circuitry and uses a clock signal in excess of 9 kHz. Student projects designed in electronic instrumentation classes without consideration of the limits imposed by these standards would fail to meet the current standards and as a result could not be marketed in the United States or Europe.

EE 430: Fundamentals of Solid State Devices

Credits: 3
Type: LEC

Develops an understanding of the operation of different semiconductor devices, starting from a quantitative knowledge of semiconductor properties.

EE 435: Java Applet Modeling for Visual Engineering Simulation

Credits: 3
Semester(s): Fall
Type: LEC

Object-oriented analysis, design and programming. Introduces Java syntax, application programmers interface (API), object-oriented programming concepts including encapsulation, inheritance, and polymorphism, and multi-threaded programming including thread synchronization and control. Also introduces graphical programming API and effective graphical programming techniques. Applies all these concepts and techniques to the student-chosen, engineering simulation projects. Emphasizes software engineering processes such as architectural design, unit refinement cycles and code reuse throughout the semester. For the project, requires students to develop a reusable class library consisting of at least three packages: a graphical drawing package, a problem simulation package, and a visualization package.

EE 438: Electrochemical Power Sources: Design, Function, and Selection

Credits: 3
Semester(s): Spring
Type: LEC

An introduction to the fundamentals of electrochemistry. Batteries as electromechanical power sources including: battery related terminology, quantitative assessment and comparison methodologies, design considerations for batteries, the chemistry and function of several classes of primary (single use) and secondary (rechargeable) battery types, and appropriate selection of power sources for applications. Students participate in design projects including the development of power systems for specific applications.

EE 441: Special Topics

Credits: 3
Type: LEC

The content of this course is variable and therefore it is repeatable for credit. The University Grade Repeat Policy does not apply.

Topics and instructors vary by semester.

EE 448: Microelectronic Device Fabrication

Credits: 3
Semester(s): Fall
Pre-requisites: EE 311
Type: LEC
Fabrication technology for microelectronic devices: crystal growth, wafer fabrication and characterization, mask fabrication, epitaxy, lithography, etching, diffusion, CVD, ion implantation, dc and RF plasma reactors (operating principles and fabrication applications), packing. Operation of microelectronic devices (interconnects, passive devices, and MOS and BJT devices), micro-optical devices (CDRs, etc.) and micro electro-mechanical devices (micro-motors, micro-mirror arrays, etc.). Students select a part of the fabrication process (lithography, diffusion, etc.) and use simulation code to design that step of the process to achieve specific device properties.

EE 449: Analog Integrated Circuit Layout

Credits: 3  
Semester(s): Spring  
Type: LEC  
Introduces analog integrated circuit fabrication and layout design for analog VLSI. Covers: representative IC fabrication processes (standard bipolar, CMOS and analog BiCMOS); layout principles and methods for MOS transistors and device matching; resistors and capacitors layout; matched layouts of R and C components; bipolar transistors and bipolar matching; and diodes. Also reviews several active-loaded analog amplifier circuits, focusing on CMOS and BiCMOS op amp configuration. Requires a term project on the layout design of simple op amp circuits involving CMOS or BiCMOS op amps plus several matched devices of resistors, capacitors and transistors. Students design circuits using SPICE simulations. The student term project is to be fabricated through MOSIS.

EE 450: Special Topics

Credits: 3  
Type: LEC  
The content of this course is variable and therefore it is repeatable for credit. The University Grade Repeat Policy does not apply.

Topics and instructors vary by semester.

EE 453: Microelectronic Fabrication Lab

Credits: 3 / 0  
Type: LEC/LAB  
Provides students with the experience of fabricating a semiconductor device. Students become versed in fabrication techniques used in the microelectronics industry. Required student activities include mask design, chemical processing, operation of clean room equipment, and testing of the final device. Also requires a report.

EE 455: Photonic Devices

Credits: 3  
Semester(s): Fall  
Type: LEC  
First, discusses the basics of p-n junctions including current flow, and recombination. In addition, discusses solar cell fundamentals, heterojunctions, metal-insulator-semiconductor devices, design, and recent advances. The course ends with a discussion of photodetector principles, design, and applications.

EE 456: RF and Microwave Circuits II

Credits: 3  
Semester(s): Spring  
Type: LEC  
The second course of a two-course sequence in the area of RF and microwave circuit design. Topics covered are filters, resonators, detectors, mixers, amplifiers, and microwave systems. Microwave Office is used for CAD analysis of circuits. Students design, construct, fabricate, and measure the performance of a microstrip resonator, a microstrip or stripline directional coupler, and a filter.

EE 458: RF/Microwave Laboratory

Credits: 3  
Semester(s): Fall  
Type: LAB/REC  
Pre-requisites: EE 401 or EE 429 or permission of instructor  
Covers RF & microwave measurement techniques in the 1 MHz to 18 GHz frequency region. Topics include assembling basic measurement systems, including attenuators, directional couplers, power dividers, terminations, power sensors, solid-state detectors, mixers, power meters, and signal generators; measuring the reflection and transmission coefficients at discrete frequencies; making similar measurements (magnitude only) over a band of frequencies using a swept power measurement system consisting of a spectrum analyzer with tracking generator; vector measurements (magnitude and phase) versus frequency using RF & microwave automatic network analyzers.

EE 459: Special Topics in Electrical Engineering

Credits: 3  
Semester(s): Fall  
Type: LEC  
The content of this course is variable and therefore it is repeatable for credit. The University Grade Repeat Policy does not apply.

Special topics of particular recent interest not covered in the standard curriculum. Requires dual registration in department office.

EE 460: Current Research Topics of Power Modulation Applications

Credits: 3  
Semester(s): Fall  
Type: LEC  
Involve a design project based on electric energy systems that specifically address power modulation applications and that is firmly based on the fundamentals needed to become a successful engineer. Students form Integrated Project Teams (IPTs) to work on the capstone project and answer all the questions that will be required of them when they leave the academic environment. Students are challenged to incorporate engineering standards and realistic constraints that include the economy, environment, sustainability, manufacturability, ethical considerations, health and safety issues, social issues, and politics as stated by ABET. Both technical reports and technical presentations are required of IPT participants.
Electrical Engineering

EE 462: Principles of Medical and Radar Imaging

Credits: 3
Semester(s): Spring
Type: LEC

Applications of multidimensional signal theory and Fourier analysis. Topics include review of signal processing tools and systems used in array imaging, including coherent receivers, pulsed and continuous wave signaling, temporal Doppler phenomenon, and monostatic, quasi-monostatic, bistatic transmitters/receivers, and 2-D signal processing; examining specific array imaging systems, including phased array imaging, synthetic aperture (SAR and ISAR) imaging, passive array imaging, and bistatic array imaging with emphasis on transmission imaging problems of diagnostic medicine and geophysical exploration.

EE 465: Current Research Topics of Pulsed Power Applications

Credits: 3 / 1
Semester(s): Spring
Type: LAB

Involves a design project based on pulsed power that utilizes the fundamentals needed to become a successful engineer in the business world. Pulsed power focuses on achieving high peak powers by impulse and rep-rate methods. Topics in this area of research include switching, surface flashover of insulators, and other related areas. Students form Integrated Project Teams to work on their projects and address the relevant issues in a multidisciplinary (electrical engineering) team. Student grades are based on peer reviewed effort, technical reports, and oral presentations.

EE 467: Integrated Power Electronics

Credits: 3
Type: LEC

Fundamental to electronic systems, i.e. sensors, communications and portable electronics, is the need to deliver electrical power. As today's electronics become smaller, so do the power circuits for conditioning and supplying power. This course introduces inductive and capacitative power switching fundamentals, circuits, and commercial ICs for designing power processing systems. Students will design a power supply including controls. The lectures will introduce patents and descriptions to augment teaching and student understanding.

EE 471: Sustainable Energy Systems

Credits: 3
Type: LEC

How can we provide clean, safe, sustainable energy supplies for the U.S. and world as a whole during the twenty-first century, despite rising population levels and increasing affluence? Examines current and potential energy systems, with special emphasis on meeting energy needs in a sustainable manner. Different renewable and conventional energy technologies will be presented and their attributes described within a global energy/environment system. Discusses political, social, and economic considerations on the development of sustainable energy/environment policies.

EE 478: Digital Design

Credits: 3
Semester(s): Spring
Type: LEC

Topics include analysis and design of clocked synchronous sequential networks; design of algorithmic state machines; analysis and design of asynchronous sequential networks; CPLDs and FPGAs; introduction to VHDL.

EE 480: Biomedical Electronics

Credits: 3
Semester(s): Fall
Type: LEC

Covers the principles and designs of various important biomedical instruments including pacemaker, EEG, ECG, EMG, and ICU equipment and diagnostic imaging devices (such as blood bank monitor, CT, MRI, mammography, ultrasound, endoscope, confocal microscope, and multiphoton non-linear microscope (2-photon fluorescent, SHG and THG). Imaging devices (e.g., CCDs) and medical image processing are also covered. Includes a general introduction to biological systems; emphasizes the structural and functional relationship between various biological compartments.

EE 482: Power Systems Engineering I

Credits: 3
Semester(s): Fall
Type: LAB

Surveys the field of modern energy systems, with the foundation being classical electrical power and related power electronics. Topics include complex power, per unit analysis, transmission line parameters and modeling, and compensation. Students also study alternative energy systems in this course. Course also includes use of a Power Simulation Program in which modeling can be done. This program is also used for the final system design project paper which accounts for 50% of the course grade.

EE 484: Communications Systems II

Credits: 3
Semester(s): Spring
Pre-requisites: EE 311
Type: LEC

Topics include review of PAM-, PDM-, PPM-pulsed modulation techniques; principles of digital communications; pulse code modulation; signal quantization; binary communications systems; M-ary communications systems; detection and parameter estimation for pulses in noise; the likelihood ratio receiver; and applications to radar signal processing.

EE 488: Fundamentals of Modern VLSI Devices

Credits: 3
Semester(s): Fall
Pre-requisites: EE 311
Type: LEC

Device fundamentals of CMOS field effect transistors and BiCMOS bipolar transistors. Device parameters and performance factors
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important for VLSI devices of deep-submicron dimensions. Reviews silicon materials properties, basic physics of p-n junctions and MOS capacitors, and fundamental principles of MOSFET and bipolar transistors. Design and optimization of MOSFET and bipolar devices for VLSI applications. Discusses interdependency and tradeoffs of device parameters pertaining to circuit performance and manufacturability. Also discusses effects in small-dimension devices: quantization in surface inversion layer in a MOSFET device, heavy-doping effect in the bipolar transistor, etc.

EE 489: Lasers and Photonics

Credits: 4  
Semester(s): Fall  
Type: LAB

Topics include an introduction to lasers and photonics; a short review of electromagnetic theory; ray tracing and lens systems; polarization of light and polarization modulators; Gaussian beams and wave propagation; optical resonators and cavity stability; spontaneous emission, stimulated emission and absorption; rate equations for gain medium; population inversion; characteristics and applications of specific lasers; waveguides and fiber optics; fiber optic communications systems; electro-optic modulators; and acoustic-optic modulators. Requires students to complete a project focusing on the design of a laser system including choice of gain medium, cavity optics, pumping mechanism, power and efficiency estimates, and cost analysis. Requires reports and presentations.

EE 490: Consumer Optoelectronics

Credits: 4  
Semester(s): Spring  
Type: LAB

Introduces optoelectronic systems. This design course emphasizes the interaction of optics, lasers, mechanics, electronics, and programming. It requires students design an optoelectronic system with a strong emphasis on team learning and teaching. Some topics of interest include: design methodology; team dynamics; light sources and detectors; light propagation; lens and mirrors; electro optics; interaction of light with materials; nonlinear optics for harmonic generation; optical detection and modulation; and discussion of selected optoelectronic devices and applications such as CD players, DVD, display systems, semiconductor lasers and light emitting diodes, laser printers, barcode scanners, digital cameras, optical coherence tomography, flow cytometry, interferometric systems and optical communications. Requires project proposal, progress reports and presentations and final written reports and presentations.

EE 491: Analog Circuits

Credits: 3  
Semester(s): Fall  
Type: LEC

Focuses on the analysis, design, simulation and mask-level chip layout of integrated analog circuits and systems. Begins with a brief review of MOSFET operation and large and small signal models. Much of the course involves designing and analyzing analog building blocks such as current mirrors, transconductance amplifiers, capacitors, multipliers, current mirrors and D/A and A/D circuits. Simultaneously, the course covers IC design and layout techniques and system analysis. It concludes by looking at sensor applications. Requires a final project consisting of a complete IC layout. Students may have the opportunity to fabricate their final project through MOSIS.

EE 494: Senior Capstone Design Project

Credits: 3  
Semester(s): Fall, Spring  
Type: SEM

Students design a useful device or product based on knowledge acquired in previous electrical engineering courses. Students have the option of creating their own projects or selecting projects from a list suggested by industrial and faculty sources.

EE 499: Independent Study

Credits: 1 - 12  
Semester(s): Fall, Spring  
Type: TUT

The content of this course is variable and therefore it is repeatable for credit. The University Grade Repeat Policy does not apply.

Independent study allows individualized guidance of a faculty member; allows students to study a particular topic that is not offered in the curriculum but is of interest to both the student and faculty member. Requires dual registration in department office.