ELECTRICAL ENGINEERING

College of Engineering

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Graduate Advisor: Fumio Hamano

General Education Advising: Academic Advising - Horn Center

Biomedical Engineering Advisor: Maryam Moussavi

Administrative Coordinator: Clarice Ross

Students desiring detailed information should contact the department office for referral to one of the faculty advisors.

Career Possibilities

Electrical Engineer • Systems Engineer • Electronics Engineer • Communications Engineer • Electrical Design Engineer • Sales Engineer • Electronics Test Engineer • Research Engineer • Consultant • Manufacturer's Representative • Safety Engineer • Quality Control Specialist • Production Manager (Some of these, and other careers, require additional education or experience. For more information, see www.careers.csulb.edu.)

Advisory and Development Council

The Department of Electrical Engineering is supported by an Advisory and Development Council consisting of outstanding engineers and executives from industry and government in southern California. Its function is to form a liaison between the University and industry and to keep the administration and faculty informed of modern engineering practices. This ensures that the curricula are kept up-to-date. It also advises on placement opportunities before and after graduation.

Accreditation

The Bachelor of Science in Electrical Engineering is accredited by the Engineering Accreditation Commission of ABET, http://www.abet.org.

Undergraduate Programs

Bachelor of Science in Electrical Engineering (126 units)

The objectives of the Bachelor of Science in Electrical Engineering Program are to prepare students to be successful and advance in their chosen careers in industry, academia, and public institutions, making significant contributions to the field of electrical engineering. These objectives are achieved by providing students:

1. a solid foundation in basic science, mathematics, and EE practices and major design skills to maintain high employability, adaptability, and an ability to develop and apply new technology;
2. effective communication skills to be able to progress in their careers;
3. an awareness of ethical and societal responsibilities;
4. an ability to work effectively in a team environment.

The bachelor's degree in electrical engineering is designed to prepare graduates for responsible engineering positions in design, development, research, applications, and operation in the fields of communications, control systems, digital signal processing systems, electromagnetics, digital and analog electronic circuits, physical electronics, computer-aided design and power systems. The curriculum is built around a strong basic core of mathematics, physics and engineering science. This is followed by intermediate courses in electrical engineering topics and finally a senior elective sequence including a senior design seminar and terminating in a capstone design course.

By choice of senior elective sequence, comprehensive coverage is provided in any one of the above fields.

Laboratory facilities are available in the engineering buildings allowing for basic as well as more advanced laboratory instruction in electronics, digital signal processing, control systems, microelectronics, communications, power, and digital systems.

Degree Progress

Students must complete the following requirements within one calendar year of declaring the major. Some students may need to take courses during Summer Session to meet these requirements. At the end of the year, students who have not met the requirements must either declare another major or meet with an advisor to determine if the student's performance in the courses merits an additional semester to complete the requirements.

First-Time Freshmen: A grade of "C" or better must be achieved in MATH 122 within one calendar year.

Transfer Students: A grade of "C" or better must be achieved in MATH 123 and PHYS 151 within one calendar year.

Requirements

Core:

Take all the following courses:

CECS 100 Critical Thinking in the Digital Information Age (or equivalent) (3)
Prerequisite/Corequisite: ENGL 100 or its equivalent.

EE 200 Trends in Electrical Engineering (1)
Prerequisites: None.

EE 201 Digital Logic Design (4)
Prerequisite: MATH 117 (or equivalent) all with a grade of "C" or better.

EE 202 Computer Methods in Engineering (3)
Prerequisites: CECS 100 and MATH 123 all with a grade of "C" or better.

EE 211 Electric and Electronic Circuits I (3)
Prerequisites: (EE 210/210L or PHYS 152) and (MATH 123 or equivalent) all with a grade of "C" or better.

EE 211L Electric Circuits Laboratory (1)
Corequisite: EE 211.

ENGR 101 Intro to the Engineering Profession (1)
Prerequisite/Corequisite: MATH 111 or MATH 113 or MATH 122.

ENGR 102 Academic Success Skills (1)
Prerequisite: ENGR 101 with a grade of "C" or better.

MATH 122 Calculus I (4)
Prerequisite: Appropriate MDPT placement or a grade of "C" or better in MATH 111 and 113, or a grade of "C" or better in MATH 117.

MATH 123 Calculus II (4)
Prerequisite: A grade of "C" or better in MATH 122.

MATH 224 Calculus III (4)
Prerequisite: A grade of "C" or better in MATH 123 or 222.

MATH 370A Applied Mathematics I (or equivalent) (3)
Prerequisites: MATH 123. Not open to Freshmen.

PHYS 151 Mechanics and Heat (4)
Prerequisite/Corequisite: MATH 122.

PHYS 254 Applied Modern Physics (3)
Prerequisite: PHYS 152 or EE 210; Prerequisite/Corequisite: MATH 224.

EE 301 Digital System Design (3)
Prerequisite: EE 201 with a grade of "C" or better.

EE 310 Signals and Systems (3)
Prerequisites: EE 211; and MATH 370A or equivalent all with a grade of "C" or better.
Corequisite: EE 202.

EE 330 Analog Electronic Circuits I (4)
Prerequisite: EE 211 with a grade of "C" or better.

EE 346 Microprocessor Principles and Applications (3)
Prerequisites: EE 201, (CECS 100 or equivalent) all with a grade of "C" or better.

EE 350 Energy Conversion Principles (3)
Prerequisites: (EE 202 or equivalent) and EE 211 and 211L all with a grade of "C" or better, or consent of instructor.

EE 360 Electromagnetic Fields (3)
Prerequisites: MATH 224, EE 310 all with a grade of "C" or better.

EE 370 Control Systems (3)
Prerequisite: EE 310 all with a grade of "C" or better.

EE 370L Control Systems Laboratory (1)
Prerequisite/Corequisite: EE 370.

EE 380 Probability, Statistics & Stochastic Modeling (3)
Prerequisites: MATH 123; (CECS 100 or equivalent) all with a grade of "C" or better.

EE 382 Communications Systems I (3)
Prerequisite: EE 310 all with a grade of "C" or better.

EE 386 Digital Signal Processing (3)
Prerequisites: EE 310 or CECS 301 all with a grade of "C" or better.

Take one of the following choices:

PHYS 152 Electricity and Magnetism (4)
Prerequisite: PHYS 151 with a grade of "C" or better.
Prerequisite/Corequisite: MATH 123.

or both of the following:

EE 210 Electro-Magnetic Foundations in EE (3)
Prerequisite: PHYS 151 all with a grade of "C" or better.
Corequisites: MATH 123, EE 210L.

EE 210L Electro-Magnetic Foundations in EE Lab (1)
Corequisite: EE 210.

Each of the foregoing courses must be completed with a grade of "C" or better as well as ENGL 100 or equivalent.

Other required courses are:

EE 400D Electrical Engineering Design Seminar and Project (2)
Prerequisites: EE 330, 370, and 382 all with a grade of "C" or better; or consent of instructor.

EE 430 Analog Electronic Circuits II (3)
Prerequisites: EE 330 and 370 all with a grade of "C" or better, or graduate standing.

EE 430L Analog Electronics II Laboratory (1)
Prerequisite/Corequisite: EE 430.

Each BSEE student must propose course work consisting of a capstone design course supported by at least two related courses, which form an area of in-depth study as approved by the EE Undergraduate Advisor. Possible areas of study include but are not limited to power, digital signal processing, controls, communications and electronics. A list showing the required supporting courses and capstone design course for each area of study is available from the EE Undergraduate Advisor. Combinations of the above areas of study or another area of study may be proposed to the EE Undergraduate Advisor. Additional elective courses must be chosen from EE 400 level courses to total at least 15 units. The entire program must total at least 126 units.

A grade of “C” or better is required for the capstone senior design course in the area of specialization.

Concurrent and/or Summer Enrollment in Another College

Students who wish to take coursework in a community college or another college to meet curricular requirements while enrolled as an undergraduate in the Department of Electrical Engineering must petition the EE Undergraduate Advisor for prior approval to enroll in specific courses. This policy is for either concurrent enrollment or summer enrollment. Prior approval for transfer credit for upper division major courses may generally be approved for no more than six semester units, subject to approval by the EE Undergraduate Advisor and the EE Department Chair who may require sufficient information to determine if each requested course is deemed equivalent to an EE course at CSULB. Exceptions require approval by vote of the EE Undergraduate Curriculum Committee.

Bachelor of Science in Engineering Option in Biomedical and Clinical Engineering (129 units)

The Department of Electrical Engineering administers an option in Biomedical and Clinical Engineering that allows the student to acquire substantive competence in biomedical engineering and biology. The program builds upon a strong base of biology, mathematics, physics, chemistry, and engineering science to develop a clinically oriented biomedical engineer to serve medical and industrial needs. It includes a core of standard electrical engineering courses as well as courses and laboratories in biomedical engineering, anatomy, physiology and biology. Elective units are available in the senior year to explore individual areas of interest.

Students planning to attend medical, dental or other health professional or graduate schools in Biomedical Engineering may select courses in Chemistry and/or Biology with the approval of the Biomedical Engineering advisor.

Laboratory facilities in the field of biomedical engineering are available in the engineering buildings; and laboratory facilities for anatomy and physiology are available on campus. Computer systems are available to simulate biological systems and to collect, process and display physiological data.

Degree Progress

Students must complete the following requirements within one calendar year of declaring the major. Some students may need to take courses during Summer Session to meet these requirements. At the end of the year, students who have not met the requirements must either declare another major or meet with an Academic Advisor to determine if the student's performance in the courses merits an additional semester to complete.

First-Time Freshmen: A grade of "C" or better must be achieved in MATH 122 within one calendar year.

Transfer Students: A grade C or better must be achieved in MATH 123 and PHYS 151 within one calendar year.

Requirements

Lower Division

Take all of the following courses:

BIOL 207 Human Physiology (4)
Prerequisites: GE Foundation requirements.

CECS 100 Critical Thinking in the Digital Information Age (3)
Prerequisite/Corequisite: ENGL 100 or its equivalent.

CHEM 111A General Chemistry (5)
Prerequisites: A passing score on the Chemistry Placement Examination . (Credit in Chem 101 does not substitute for a passing score on the Chemistry Placement Examination) and a "C" or better in MATH 113 or 117 or 119A or 122. One year of high school chemistry is strongly recommended. (Recommended for students who intend to pursue careers in science or engineering).

EE 200 Trends in Electrical Engineering (1)
Prerequisites: None.

EE 201 Digital Logic Design (4)
Prerequisite: MATH 117 (or equivalent) all with a grade of "C" or better.

EE 202 Computer Methods in Engineering (3)
Prerequisites: CECS 100 and MATH 123 all with a grade of "C" or better.

EE 211 Electric and Electronic Circuits I (3)
Prerequisites: (EE 210/210L or PHYS 152) and (MATH 123 or equivalent) all with a grade of "C" or better.

EE 211L Electric Circuits Laboratory (1)
Corequisite: EE 211.

MATH 122 Calculus I (4)
Prerequisite: Appropriate MDPT placement or a grade of "C" or better in MATH 111 and 113, or a grade of "C" or better in MATH 117.

MATH 123 Calculus II (4)
Prerequisite: A grade of "C" or better in MATH 122.

MATH 224 Calculus III (4)
Prerequisite: A grade of "C" or better in MATH 123 or 222.

PHYS 151 Mechanics and Heat (4)
Prerequisite/Corequisite: MATH 122.

PHYS 152 Electricity and Magnetism (4)
Prerequisite: PHYS 151; Prerequisite/Corequisite: MATH 123.

PHYS 254 Applied Modern Physics (3)
Prerequisite: PHYS 152 or EE 210; Prerequisite/Corequisite: MATH 224.

Each of the foregoing courses must be completed with a grade of "C" or better as well as ENGL 100 or equivalent. The interdisciplinary courses as well as the Communications Studies (COMM) courses required for General Education must be taken for a letter grade.

Upper Division:

Take all of the following courses which must be completed with a "C" or better:

EE 310 Signals and Systems (3)
Prerequisites: EE211; and MATH 370A all with a grade of "C" or better or equivalent.
Corequisite: EE 202.

EE 330 Analog Electronic Circuits I (4)
Prerequisite: EE 211 all with a grade of "C" or better.

EE 346 Microprocessor Principles and Applications (3)
Prerequisites: EE 201, (CECS 100 or equivalent).

EE 360 Electromagnetic Fields (3)
Prerequisites: MATH 224, EE 310 all with a grade of "C" or better.

EE 370 Control Systems (3)
Prerequisite: EE 310 all with a grade of "C" or better.

EE 370L Control Systems Laboratory (1)
Prerequisite/Corequisite: EE 370.

EE 382 Communication Systems I (3)
Prerequisite: EE 310 with a grade of "C" or better.

EE 386 Digital Signal Processing (3)
Prerequisites: EE 310 or CECS 301 all with a grade of "C" or better.

EE 406 Medical Instrumentation and Measurements (3)
Prerequisite: EE 330 with a grade of "C" or better or consent of instructor or graduate standing.

EE 406L Biomedical Engineering Laboratory (1)
Prerequisite/Corequisite: EE 406.

EE 407 Applications of Computers in Medicine (3)
Prerequisite: EE 346 with a grade of "C" or better or consent of instructor or graduate standing.

EE 430 Analog Electronic Circuits II (3)
Prerequisites: EE 330 and 370 all with a grade of "C" or better, or graduate standing.

EE 444 Microprocessor Based System Design (3)
Prerequisites: EE 346 with a grade of "C" or better or graduate standing.

MATH 370A Applied Mathematics I (3)
Prerequisites: MATH 123. Not open to Freshmen.

Select one course from the following:

MAE 330 Engineering Thermodynamics I (3)

CE 370 Analytical Mechanics (3)

Take additional approved biomedical electives, including an approved senior design course to at least 129 units.

Bachelor of Science in Electronics Engineering Technology

For requirements and courses, see description in the Engineering Technology Programs section of this catalog.

Bachelor of Science in Computer Engineering Technology

For requirements and courses, see description in the Engineering Technology Programs section of this catalog.

Graduate Programs

Master of Science in Electrical Engineering

This program affords an opportunity for engineers and others to advance their competency in analysis and design to better meet the high technology needs of local industry. Each student selects two core courses and three graduate courses in one area of emphasis, and the remaining courses must augment and support the area of emphasis. Some current examples of areas of emphasis are biomedical, communications, computer/communication networks and security, control systems and robotics, digital signal processing, digital and computer systems, electromagnetics and optics, electronics, networks and filters, and power. Students may create other areas of emphasis with the approval of the graduate advisor. Students will choose one of the three alternatives: thesis, project, and course-only. Successful completion of a thesis provides a unifying culmination to the program, and an enhanced resume for future industrial or academic endeavor. A limited number of laboratory and teaching assistantships are available to qualified graduate students.

Prerequisites

1. A bachelor's degree from an accredited program in electrical engineering or a bachelor's degree from an accredited engineering, natural science or other appropriate program with the requirement that essential undergraduate deficiencies in electrical engineering are removed prior to Advancement to Candidacy.
2. The prospective graduate student must have attained a GPA of at least 2.7 for the last 60 semester units (90 quarter units) attempted prior to entry in the MSEE program.

   The student should apply online at CSU Mentor. Do not send an application to the Department. International students should apply online at CSU Mentor or through the Center for International Education.

Requirements

Take at least 2 out of the below 5 courses appropriate to area of emphasis and subject to graduate advisor approval:

EE 503 Advanced Systems Engineering (3)
Prerequisite: EE 411 with a grade of "C" or better or equivalent mathematical maturity.

EE 505 Advanced Engineering Mathematics for EE (3)
Prerequisites: Consent of instructor.

EE 508 Probability Theory and Random Processes (3)
Prerequisite: EE 380 with a grade of "C" or better.

EE 509 Network Theory (3)
Prerequisites: EE 386, 410 or 430 all with a grade of "C" or better.

EE 511 Linear Systems Analysis (3)
Prerequisite: EE 411 or 470 all with a grade of "C" or better or equivalent mathematical maturity.

Complete 30 unit minimum in 400-, 500-, or 600-level courses as approved in advance by the graduate advisor.

Take one of the following three alternatives:

1. Thesis Alternative:
   500/600-level EE courses including core (15 units);
   EE 697 Directed Research (3);
   EE 698 Thesis or Industrial Project (6);
   400/500/600-level courses in EE (6 units);
   Comprehensive Oral Exam on Thesis.
2. Project Alternative:
   500/600-level EE courses including core (21 units);
   EE 697 Directed Research (3) (on a capstone project);
   400/500/600-level EE courses (6 units);
   Comprehensive Oral Exam on the capstone project.
3. Course-Only Alternative:
   500/600-level EE courses including core and at least three courses forming area of emphasis (24 units);
   400/500/600-level EE courses (6 units);
   Comprehensive Oral Exam on the area-of-emphasis.

Tentative Program

Upon matriculation graduate students must consult with the graduate advisor and a tentative program must be approved by the advisor by a few weeks into the first semester. The program must contain two core courses and exhibit an area of emphasis comprised of at least three related graduate courses (500 or 600 level). Students should obtain the MSEE Handbook, which covers the procedures and requirements, from the advisor or Electrical Engineering Department office or Electrical Engineering web.

Advancement to Candidacy

At least one semester before the graduating semester students must advance to candidacy. To apply for advancement to candidacy students must satisfy the following requirements:

1. All deficiencies must have been made up with a GPA of at least 3.0.
2. Currently enrolled in a regular session.
3. Demonstration of competence in technical writing by passing an appropriate writing course such as ENGL 317, 417, 418, or 419 with a grade of "C" or better or by providing acceptable proof of technical writing ability to the graduate advisor. This requirement can be waived for thesis or project students upon recommendation of the graduate advisor.
4. Fulfillment of the Graduation Writing Assessment Requirement (GWAR).
5. Completion of at least 9 units as a graduate student in residence while maintaining both an overall GPA and a program GPA of at least 3.0. Students are advised to seek advancement before completing 15 units of the program.

Ph.D. in Engineering and Industrial Applied Mathematics

For requirements, see the description in the College of Engineering section of this catalog.

Courses (E E)

LOWER DIVISION

200. Trends in Electrical Engineering (1)

Electrical Engineering as a profession. Nature of professional and design activities. Advances in Electrical Engineering. Current designs, future trends and challenges in various fields of Electrical Engineering.

(Lecture 1 hour) Letter grade only (A-F).

201. Digital Logic Design (4)

Prerequisite: MATH 117 (or equivalent) with a grade of "C" or better.

Practical design of digital circuits. Basic topics in combinational and sequential switching circuits with applications to the design of digital devices.

(Lecture-problems 4 hours)

202. Computer Methods in Engineering (3)

Prerequisites: CECS 100 and MATH 123 all with a grade of "C" or better.

Introduction to MATLAB and numerical methods with applications to engineering. Programming in MATLAB. Introduction to SIMULINK and other MATLAB toolboxes.

(Lecture 2 hours, laboratory 3 hours) Letter grade only (A-F). Not open for credit to students with credit in ENGR 202.

210. Electro-Magnetic Foundations in Electrical Engineering (3)

Prerequisite: PHYS 151 all with a grade of "C" or better.
Corequisites: MATH 123, EE 210L.

Electric fields. Magnetic fields. Ohm's law. Kirchoff's laws. Physics of inductance and capacitance. Conservation of energy. Introduction to RL, RC and RLC circuits. Introduction to phasors. Introduction to electric machinery, computer electronics, electromagnetic radiation, and communication.

(Lecture-problems 3 hours) Letter grade only (A-F).

210L. Electro-Magnetic Foundations in Electrical Engineering Laboratory (1)

Corequisite: EE 210.

Laboratory experiments demonstrating behavior of resistive circuits; capacitors and inductors; transient RL and RC circuits; sinusoidal (phasor) RL, RC and RLC circuits; motors, generators, and transformers.

Letter grade only (A-F).

211. Electric and Electronic Circuits (3)

Prerequisites: (EE 210/210L or PHYS 152) and (MATH 123 or equivalent) all with a grade of "C" or better.

Linear circuit analysis techniques including circuit transformations, mesh and node analyses. Thevenin's, Norton's, Superposition, and Maximum Power Transfer theorems. Transient analysis of RL, RC and RLC circuits. Phasors. Power concepts. Nonlinear circuits including diodes. Circuit solution using PSpice.

(Lecture-problems 3 hours) Letter grade only (A-F).

211L. Electric Circuits Laboratory (1)

Corequisite: EE 211.

Laboratory investigation of Ohm's Law, Kirchhoff's Laws, voltage and current division, mesh and nodal analysis, Thevenin and Norton equivalents, superposition, simple RL, RC, RLC circuits, phasors. Use of voltmeters, ammeters, ohmmeters and oscilloscopes. Identification of unknown elements.

(Laboratory 3 hours) Letter grade only (A-F).

220. Materials Sciences for Electrical Engineers (3)

Prerequisites: MATH 224 and EE 210 all with a grade of "C" or better.

Basic principles of optical and wave propagation. Introduction to quantum electronics. Fundamental aspects of photonics and materials sciences and their relevance to solid state electronic circuits.

Letter grade only (A-F). (Lecture-problems 3 hours)

236. Introduction to Nanotechnology: A Tour in Nano-Land (3)

Prerequisite: Sophomore standing.

Overview of the fundamentals of nanoscience and nanotechnology, a wide range of applications, and issues that affect widespread use of these technologies based on ongoing research and discourse. An interdisciplinary course, taught by an interdisciplinary team of Instructors. Students will observe nature and matter in submicron and nanometer scale.

(Lecture-problems 3 hours) Letter grade only (A-F).

248. Security, Information Assurance, and Computers (3)

Computer security and information assurance as crucial challenges, consequences for individuals, economy, and society as a whole. Security threats and vulnerabilities in the use of computer systems. Tools and controls to reduce or block these threats. Law, privacy, and ethics.

(Lecture-problems 3 hours) Letter grade only (A-F).

260. Analytical Methods for Electromagnetics (4)

Prerequisite: EE 210 or PHYS 152 or equivalent all with a grade of "C" or better.

Fundamental concepts and analytical methods for electromagnetics.

(Lecture 3 hours, problem session 2 hours.) Letter grade only (A-F).

UPPER DIVISION

301. Digital System Design (3)

Prerequisite: EE 201 with a grade of "C" or better.

FPGA based digital design. Implementation of FPGA digital hardware systems based on the algorithms and implementation requirements using hardware description languages, optimization, logic synthesis, place and route methods. Implementation of finite state machines.

(Lecture-problems 2 hours, laboratory 3 hours) Letter grade only (A-F).

310. Signals and Systems (3)

Prerequisites: EE211; and MATH 370A or equivalent all with a grade of "C" or better.
Corequisite: EE 202.

Fundamental concepts of signals and systems. Laplace Transforms. Fourier Series. Fourier Transforms. Two-port parameters.

(Lecture-problems 3 hours) Letter grade only (A-F).

315. Introduction to Systems Analysis (3)

Prerequisite: MATH 123 with a grade of "C" or better.

System definitions: linear, nonlinear, continuous, discrete. Analytical, and qualitative solution of nonlinear systems. Linear system analysis and solutions. Introduction to complex algebra. Discrete systems modeling, analysis, solutions. State space representation and stability analysis. Introduction to linear and matrix algebra.

(Lecture-problems 2 hours, laboratory 3 hours) Letter grade only (A-F).

330. Analog Electronic Circuits I (4)

Prerequisite: EE 211 with a grade of "C" or better.

Analysis and design of diode, bipolar junction transistor, field-effect transistor (MOSFET and JFET), and CMOS circuits. Op-Amp linear and nonlinear circuit applications. Digital electronic circuits. Laboratory includes transistor and operational amplifier circuit design and CAD tools.

(Lecture-problems 3 hours, laboratory 3 hours) Letter grade only (A-F).

332. Digital Electronic Circuits (3)

Prerequisites: EE 201, 211, 420 all with a grade of "C" or better.

Analysis and design of digital electronic circuits. Structure and operation of MOS transistors, including SPICE models. NMOS and CMOS inverters. Bipolar transistor inverters. Bipolar digital gate circuits (TTL & ECL). Regenerative logic circuits (flip-flop, Schmitt trigger, multivibrator). Semi-conductor memories. Basic IC design-Gate Array, Standard Cell, PLA.

(Lecture-problems 3 hrs) Letter grade only (A-F).

346. Microprocessor Principles and Applications (3)

Prerequisites: EE 201, (CECS 100 or equivalent) all with a grade of "C" or better.

Introduction to the design of modern RISC based microprocessors and microcontrollers. Programming problems written in C++ and assembly using the critical thinking skills learned in CECS100. Architectural principles learned in the classroom illustrated using the assembly programming language.

Letter grade only (A-F). (Lecture-problems 2 hours, lab 3 hours)

350. Energy Conversion Principles (3)

Prerequisites: (EE 202 or equivalent) and EE 211 and 211L, or consent of instructor all with a grade of "C" or better.

Electromechanical energy conversion. Power transformers. DC, synchoronous, and induction machines. Laboratory experiments on power electronics and rotating machinery.

Letter grade only (A-F). (Lecture-problems 2 hours, lab 3 hours).

360. Electromagnetic Fields (3)

Prerequisites: MATH 224, EE 310 all with a grade of "C" or better.

Electric and magnetic field theory including propagation of plane waves in lossless and dissipative media. Maxwell's equations. Transmission lines and waveguides.

(Lecture-problems 3 hours) Letter grade only (A-F). Not open for credit to students with credit in EE 460.

370. Control Systems (3)

Prerequisite: EE 310 with a grade of "C" or better.

Control systems analysis; block diagrams, signal flow graphs, stability criteria, root locus, frequency domain analysis. Examples of classical control system design.

Letter grade only (A-F). (Lecture-problems 3 hours).

370L. Control Systems Laboratory (1)

Prerequisite/Corequisite: EE 370.

Experiments which reinforce concepts learned in EE 370. Digital simulation modeling, analysis, and design. Real time applications.

Letter grade only (A-F). (Laboratory 3 hours)

380. Probability, Statistics, and Stochastic Modeling (3)

Prerequisites: MATH 123; (CECS 100 or equivalent) all with a grade of "C" or better.

Probability with an emphasis on computer modeling of probabilistic systems. Topics such as discrete and continuous random variables, moments, correlation, covariance, Markov processes and queuing theory presented from a mathematical foundation developed and exemplified with realistic computer simulations from students.

Letter grade only (A-F). (Lecture 2 hrs, aboratory 3 hrs)

382. Communication Systems I (3)

Prerequisite: EE 310 with a grade of "C" or better.

Review of Fourier series and transforms. Introduction to passive, active, and digital filters. Basic elements of probability theory, statistics, concept of white noise, AM, DSB, SSB and vestigial modulation, narrowband and wideband FM.

Letter grade only (A-F). (Lecture-problems 2 hours, lab 3 hours)

386. Digital Signal Processing (3)

Prerequisites: EE 310 or CECS 301 all with a grade of "C" or better.

Introduction to discrete-time signals and systems, z-transform, digital filters, system design, and comparison to the analog counterparts. Multimedia-based laboratory experiments for discrete-time signals and systems in time and frequency domain, synthesis of digital sound/music with MATLAB or C.

Letter grade only (A-F). Not open for credit to students with credit in EE 485. (Lecture-problems 2 hours, laboratory 3 hours)

400D. Electrical Engineering Design Seminar and Project (2)

Prerequisites: EE 330, 370, and 382 all with a grade of "C" or better; or consent of instructor.

Design terminologies, processes and issues. Simple design examples. Constraints imposed by factors such as performance, economics, reliability, safety, aesthetics, packaging, codes, standards and practices. Ethics and social and environmental impact. Case studies. Individual and group projects. Oral presentation required.

(Lecture-problems 1 hour, laboratory 3 hours) Letter grade only (A-F).

401. Mathematical Methods for Electrical Engineers (3)

Prerequisite: MATH 370A with a grade of "C" or better.

Analytic techniques relevant to electrical engineering.

Letter grade only (A-F). (Lecture-problems 3 hours).

402./502. Engineering Modeling and Simulation (3)

Prerequisite: EE 380 with a grade of "C" or better.

Fundamental techniques of modeling and simulation of complex engineering systems. Next generation simulation tools (DES), Output analysis of systems. Alternative system configurations. Variance reduction techniques. Project proposal developments.

Projects required for EE 502. (Lecture-problems 3 hours). Letter grade only (A-F).

403. Systems Engineering (3)

Prerequisites: ENGR 203 or EE 202 all with a grade of "C" or better, or graduate standing.

Modeling and analysis, and design of deterministic and stochastic systems. The building blocks of Systems Engineering models ranging from network models with special structured, to unstructured linear and nonlinear optimization.

Letter grade only (A-F). (Lecture-problems 3 hours)

405. Selected Topics in Electrical Engineering (3)

Prerequisites: Senior standing in electrical engineering or consent of instructor or graduate standing.

Selected topics from recent advances in electrical engineering.

Letter grade only (A-F). May be repeated to a maximum of 6 units with undergraduate advisor consent. Topics announced in *Schedule of Classes*. (Lecture-problems 3 hours).

406. Medical Instrumentation and Measurements (3)

Prerequisite: EE 330 with a grade of "C" or better or consent of instructor or graduate standing.

Design and analysis of medical instruments, electrodes and amplifiers for measurement of physiological signals.

Letter grade only (A-F). (Lecture-problems 3 hours)

406L. Biomedical Engineering Laboratory (1)

Prerequisite/Corequisite: EE 406.

Laboratory study of medical instrumentation, transducers and computer data processing.

(Laboratory 3 hours) Letter grade only (A-F).

407. Applications of Computers in Medicine (3)

Prerequisite: EE 346 with a grade of "C" or better or consent of instructor or graduate standing.

Principles of analysis and design of computers and data collection equipment for real-time on-line medical systems.

(Lecture-problems, computer projects 3 hours) Letter grade only (A-F).

410. Analog Filter Design (3)

Prerequisite: EE 310 with a grade of "C" or better or graduate standing.

Theory and design of active filters using operational amplifiers. Emphasis is placed on low-pass filters.

Lecture-problems 3 hours) Letter grade only (A-F).

411. Continuous- and Discrete-Time Linear Systems (3)

Prerequisite: EE 370 with a grade of "C" or better or graduate standing.

Review of matrices and linear algebra. Z-transforms, linear systems, and difference equations. State-space description of linear systems. Analysis including stability, reachability, and observability. State-feedback.

(Lecture-problems 3 hours) Letter grade only (A-F).

412. Fractals in Engineering (3)

Prerequisite: EE 310 with a grade of "C" or better or graduate standing.

Application of fractal geometry to system theory. Study of system dynamics leading to complex behaviors and chaos. Scaling laws, sensitivity to initial conditions, strange attractors, and i/f noise will also be discussed.

(Lecture-problems 3 hours). Letter grade only (A-F).

420. Solid State Electronic Devices (3)

Prerequisite: PHYS 254 with a grade of "C" or better or graduate standing.

Semiconductor crystal structure and growth. Carrier modeling, drift and diffusion currents. P-N junctions, diodes, solar cells and light-emitting diodes (LED). Bipolar junction transistor (BJT) biasing, linear and switched operation. Metal oxide semiconductor field effect transistor (MOSFET) operation. Solar cells, photovoltaics, and lasers.

Not open for credit to students with credit in EE 320. (Lecture-problems 3 hours) Letter grade only (A-F).

427./527. Digital Filter Design and Audio Processing (3)

Prerequisite: EE 386 with a grade of "C" or better or consent of instructor.

Digital filter design methods, filter architectures, round-off noise, implementation and applications to audio signal processing. Additional projects required for EE 527.

(Lecture-problems 3 hours) Letter grade only (A-F).

428./528. Speech Signal Processing (3)

Prerequisite/Corequisite: EE 486 or consent of instructor.

Principles and engineering applications of speech signal processing. Speech synthesis, recognition, encoding, and compression. Applications of neural networks.

Additional projects required for EE 528. (Lecture-problems 3 hours) Letter grade only (A-F).

430. Analog Electronic Circuits II (3)

Prerequisites: EE 330 and 370 with a grade of "C" or better, or graduate standing.

Differential pairs, current sources, output stages, and integrated operational amplifiers. Op-amp applications and practical issues. Frequency response. Computer-aided circuit analysis and design. Feedback amplifiers and stability. Oscillators.

(Lecture-problems 3 hours) Letter grade only (A-F).

430L. Analog Electronics Laboratory II (1)

Prerequisite/Corequisite: EE 430.

Advanced transistor, operational amplifier, and linear-integrated circuits and systems design laboratory.

Not open for credit to students with credit in EE 433L. (Laboratory 3 hours) Letter grade only (A-F).

434./534. Mixed-Signal IC Design (3)

Prerequisites: EE 201 and 330 all with a grade of "C" or better or consent of instructor.

CMOS fabrication. Component layout. MOSFET modeling. Mixed-signal devices such as D/A and A/D converters and phase-locked loops. Substrate Noise coupling. System-on-chip considerations. Design using CAD tools.

Additional projects required for EE 534. (Lecture-problems 2 hours, Laboratory 3 hours) Letter grade only (A-F).

435./535A. Microelectronics (3)

Prerequisites: EE 201 and 330 all with a grade of "C" or better.

Theory of microelectronics integrated circuit design, IC fabrication technology, device characterization, modelling, digital and analog simulation tools, physical layout tools, digital standard cell library design, IC digital system designs, I/O pad design, full chip simulation and physical designs.

Additional projects required for EE535A. (Lecture-problems 3 hours) Letter grade only (A-F).

435L. Microelectronics Laboratory (1)

Corequisite: EE 435.

Laboratory evaluation of IC process steps. Wafer probe, packaging, and final test. Empirical device model formulation from test data.

Not open for credit to students with credit in EE 420L. (Laboratory 3 hours) Letter grade only (A-F).

436./536. Microfabrication and Nanotechnology (3)

Prerequisites: EE 330 and PHYS 254; or MAE 300 all with a grade of "C" or better.

Techniques and the technology of miniaturization of electrical, mechanical, optical, and opto-electronic devices in sizes from millimeters to nanometers. Design examples of sensors, microlenses, cantilevers, and micromotors, process fabrication.

Additional projects required for EE 536. (Lecture-problems 3 hours) Letter grade only (A-F).

437. Multidisciplinary Nano-Science and Engineering (3)

Prerequisite: Consent of instructor or graduate standing.

Introduces four key areas: nanoscience properties of materials; nanotechnology in biology and nature; observation, measurement, analysis; applications. Importance of understanding and engineering nanoscale structures, materials, and processes for the 21st Century. Use of scanning electron microscope and atomic force microscope.

(Lecture-problems 2 hours, laboratory 3 hours) Letter grade only (A-F).

443. System-on-Chip Architecture and Applications (3)

Prerequisite: EE 346 with a grade of "C" or better or consent of instructor or graduate standing.

Introduction to System-on-Chip Architecture by using ARM's MCU and MMU. Concepts and methodologies in designing a system-on-chip (SoC) based microprocessor core. Principles of modern SoC and processor design. Embedded applications based around SoC processor cores.

(Lecture-problems 2 hours, laboratory 3 hours) Letter grade only (A-F).

444. Microprocessor Based System Design (3)

Prerequisites: EE 346 with a grade of "C" or better or graduate standing.

Study of microprocessor based systems and their integration with peripheral devices including sensors, actuators, and serial communications. Following a progressive lab sequence, over the semester the student will design and construct a modern RISC microcontroller based system.

(Lecture-problems 2 hours, laboratory 3 hours) Letter grade only (A-F). Not open for credit to student with credit in EE 347.

446. Advanced Microprocessors and Embedded Controllers I (3)

Prerequisite: EE 444 with a grade of "C" or better or consent of the instructor or graduate standing.

Advanced microprocessors such as Pentium series, RISC, and CISC. Hardware features and new instructions. Support for virtual memory, paging, privilege levels, multitasking and internal cache. Floating point coprocessors. Embedded controllers, on-chip resources and applications.

(Lecture-problems 2 hours, laboratory 3 hours) Letter grade only (A-F).

447. Design of Electronic Systems (3)

Prerequisites: (EE 301 or 435) and EE 346 and EE 430 all with a grade of "C" or better, or graduate standing.

Prerequisitie/Corequisite: EE 400D or graduate standing.

Extensive laboratory projects. Design of analog and digital systems. Computer-aided design including, for example, hardware descriptive language (HDL) and SPICE.

(Lecture-problems 2 hours. laboratory 3 hours) Letter grade only (A-F).

448./548. Wireless and Mobile Networks and Security in Wireless Networks (3)

Prerequisite: EE 482 with a grade of "C" or better or equivalent.

Wireless and Mobile Ad-hoc Networks and Security. Ad-hoc and geographic routing, resource discovery, MAC, IP-mobility, mobility modelling, wired-wireless networks, security aspects. Lab Projects will include use of tools such as OPNET, Ethereal, Sniffer, Scanner, IDS, etc.

Advanced project required for EE 548. (Lecture-problems 3 hours) Letter grade only (A-F).

449. Topics in Multimedia and Hypermedia (3)

Prerequisite: EE 483 with a grade of "C" or better or equivalent.

Theoretical and practical issues in designing multimedia systems, design and implementation of interactive multimedia and hypermedia applications including interactive television (e.g., video-on-demand, eLearning), hypermedia systems (e.g., the World Wide Web), and video conferencing and groupware. Emphasis placed on current design issues and research topics.

Extra project for graduate students. (Lecture-problems 3 hours) Letter grade only (A-F).

450. Electronic Control of Motors (3)

Prerequisite: EE 350 with a grade of "C" or better or graduate standing.

Prerequisites/Corequisites: EE 370 or graduate standing.

Characteristics of semiconductor power switches. Modeling and application of control theory to various types of motors. Bidirectional and four-quadrant converter topologies for motion control. Selection of drives to control AC and DC motors. Uninterruptible power supplies and adjustable speed drives.

(Lecture-problems 3 hours) Letter grade only (A-F).

451. Electric Vehicles (3)

Prerequisites: EE 350 and (EE 370 or MAE 376) all with a grade of "C" or better; or graduate standing.

Electric propulsion systems for electric and hybrid electric vehicles. DC and AC motor drives. Brushless DC motors. Switched reluctance motors. Energy storage systems including batteries and supercapacitors. Electric Vehicle Mechanics and Drivetrain.

(Lecture-problems 3 hours) Letter grade only (A-F).

452. Computer Applications in Power Systems (3)

Prerequisite: EE 350 with a grade of "C" or better or consent of instructor or graduate standing.

Modeling of power generation, transmission, and distribution systems, load-flow analyses, short-circuit studies, voltage drop and power loss calculations, transient stability and optimal power flow analyses. Application of specialized computer software for power system design and analyses.

(Lecture-problems 3 hours) Letter grade only (A-F).

453./553. Protection of Power Systems (3)

Prerequisites: EE 310, 350 all with a grade of "C" or better.

Protective relays, instrument transformers, low-voltage and high-voltage circuit breakers, protection of generators and motors, transformer protection and transmission line protection. Relay coordination and commercial power systems. Application of computer programs for protective device coordination. Additional projects required for EE 553.

(Lecture-problems 3 hours) Letter grade only (A-F).

455./555. Space Electric Power Systems (3)

Prerequisites: EE 330 and 350 all with a grade of "C" or better.

A comprehensive treatment of characteristics of and requirements from spacecraft power systems, power sources, power conversion and control. Energy storage, electrical equipment, power converters and loads, power management. Future space missions and technological needs. Additional projects required for EE 555.

(Lecture-problems 3 hours) Letter grade only (A-F).

458. Design of Power System Components (3)

Prerequisites: EE 330 and (either EE 450 or EE 452 or EE 453) all with a grade of "C" or better; or graduate standing.

Prerequisitie/Corequisite: EE 400D or graduate standing.

Design of electrical, electronic and electromechanical components required for power conversion, control, transmission, distribution, protection and measurements in terrestrial and space electric power systems.

(Lecture-problems 2 hours, laboratory 3 hours) Letter grade only (A-F).

462. Electromagnetics and Applications to Wireless Systems (3)

Prerequisite: EE 310 with a grade of "C" or better or graduate standing.

Electromagnetic field theory including transmission lines, vector fields, electrostatics and magnetostatics.

Maxwell's equations and plane wave propagation. Waveguides and microstrip-RF circuit principles and devices. Radiation and antenna design. Wireless communication systems including satellite and cell-phone technologies.

Letter grade only (A-F). Not open for credit to students with credit in EE 460 or 464. (Lecture-problems 2 hours, laboratory 3 hours)

464. Electromagnetics and Applications to Electro-Optics (3)

Prerequisite: EE 310 with a grade of "C" or better or graduate standing.

Electromagnetic field theory including transmission lines, vector fields, electrostatics and magnetostatics. Maxwell's equations and plane wave propagation. Electromagnetic formulation of geometric and Fourier optics. Semiconductor and gas laser applications to fiber-optic communication systems and electro-optic devices.

Not open for credit to students who have credit in EE 460 or 462. (Lecture-problems 2 hours, laboratory 3 hours) Letter grade only (A-F).

470. Digital Control (3)

Prerequisites: EE 370, EE 370L, and (EE 386 or EE 411) all with a grade of "C" or better, or graduate standing.

Analysis and synthesis of digital control systems. General application of both the Z-transform and the state-space approach for discrete system design.

(Lecture-problems 2 hours, laboratory 3 hours) Letter grade only (A-F).

471. Design of Control Systems (3)

Prerequisite: EE 370 with a grade of "C" or better or graduate standing.

Prerequisitie/Corequisite: EE 400D.

Design of compensators using root-locus and Bode-plot methods. Design of state-space control systems and observers. Computer-aided design.

(Lecture-problems 2 hours, laboratory 3 hours) Letter grade only (A-F).

474./574. Robot Modeling and Control (3)

Prerequisite: EE 370 with a grade of "C" or better.
Recommended: EE 411 or 511

Basic methodology for analysis and design of robotic manipulators. Classification of robots. Homogeneous transformations, kinematics, dynamics, trajectory planning and control of robots. Application of robots in flexible manufacturing. Advanced projects required for EE 574. EE 411 or 511 is recommended as a pre/corequisite.

(Lecture-problems 3 hours) Letter grade only (A-F).

476./576. Neural Networks and Fuzzy Logic (3)

Prerequisite: EE 386 with a grade of "C" or better or consent of instructor.

Principles and application of artificial neural networks and fuzzy logic. Mechanisms of supervised and unsupervised neural networks. Fuzzy control systems. Applications in signal processing, communications, control, and other areas.

Additional projects required for EE 576. Not open for credit to students with credit in EE 589/689. (Lecture-problems 3 hours) Letter grade only (A-F).

481./581. Satellite Communication Systems (3)

Prerequisite: EE 482 with a grade of "C" or better.

Basic orbital mechanics, link analysis, multiple access architectures and protocols, FDMA, TDMA, and CDMA systems. Synchronization techniques, modulation and coding techniques. Security and spread spectrum requirements. System design.

Additional projects required for EE 581. (Lecture-problems 3 hours) Letter grade only (A-F).

482. Communication Systems II (3)

Prerequisite: EE 382 with a grade of "C" or better or graduate standing.

Information sources and communication systems. Orthogonal series representation of signals, pulse and digital modulation techniques, band-pass digital communication systems, special topics in communications.

(Lecture-problems 3 hours) Letter grade only (A-F).

483. Digital Image Processing (3)

Prerequisite: EE 386 with a grade of "C" or better or graduate standing.

Image formation. Image detectors and their characteristics. Perception, image models. Sampling and quantization. Pixel relationships. Statistical characterization of discrete images - probability density models. Image fidelity criteria and image intelligibility. Image transforms. Image enhancement techniques.

(Lecture-problems 3 hours) Letter grade only (A-F).

486. Digital Signal Processing for Multimedia Communications (3)

Prerequisite: EE 386 with a grade of "C" or better or graduate standing.

Discrete-time signals and systems, discrete Fourier transform, fast Fourier transform, spectral estimation, interpolation and decimation, filter design and structures and applications to multimedia communications. Laboratory projects for image processing, FFT receiver, signal detection, digital phase-locked loop.

(Lecture-problems 2 hours, laboratory 3 hours) Letter grade only (A-F).

488. Communication System Design (3)

Prerequisite/Corequisite: (EE 400D, EE 430, and EE 482), or graduate standing.

Design of Communication systems/subsystems and their implementation in software and hardware. Design of Capstone Senior Project in the area of Communication systems.

(Lecture-problems 2 hours, laboratory 3 hours). Letter grade only (A-F).

489. Digital Signal Processing Design (3) S

Prerequisities/Corequisites: (EE 400D and 486) or graduate standing.

Design, implementation, and real-time testing of projects such as FIR filters, IIR filters, tone generator, 32-bit addition and multiplication, FFT spectrum analyzer. All projects are simulated in fixed-point arithmetic with MATLAB or C and TMS320C54x assembly code in bit-exact.

(Lecture-problems 2 hours, laboratory 3 hours) Letter grade only (A-F).

490. Special Problems (1-3)

Prerequisites: Minimum G.P.A. of 2.5 and consent of instructor.

Assigned topics in technical literature or laboratory projects and reports.

May be repeated to a maximum of 6 units. Letter grade only (A-F).

492. Instrumentation and Data Acquisition for Engineering Applications (3)

Prerequisites: (EE 370 and EE 370L) all with a grade of "C" or better, or consent of instructor or graduate standing.

Concepts of instrumentation, data acquisition and computer-based control of industrial systems. Topics include signal conditioning, software and hardware for data acquisition and computer-based control, graphical programming and virtual instrumentation.

(Lecture-problems 2, laboratory 3 hours) Letter grade only (A-F).

GRADUATE LEVEL

502./402. Engineering Modeling and Simulation (3)

Prerequisite: EE 380 with a grade of "C" or better.

Fundamental techniques of modeling and simulation of complex engineering systems. Next generation simulation tools (DES), Output analysis of systems. Alternative system configurations. Variance reduction techniques. Project proposal developments.

Additional projects required for EE 502. (Lecture-problems 3 hours). Letter grade only (A-F).

503. Advanced Systems Engineering (3)

Prerequisite: EE 411 with a grade of "C" or better or equivalent mathematical maturity.

Modeling and analysis, and design of deterministic and stochastic systems. The building blocks of engineering optimization models ranging from network models with special structured, to unstructured linear and nonlinear optimization.

Letter grade only (A-F). (Lecture-problems 3 hours)

504. Introduction to Entrepreneurship for Engineers (3)

Prerequisite: Graduate standing in engineering or computer science.

Core business concepts and issues, essence of leadership. Understanding of finance, marketing, sales, and management issues from practical entrepreneurial perspective through classroom discussion, guest speakers' seminars, case study, and creation of business plan based on student's specific area of interest.

(Lecture-problems 3 hours) Letter grade only (A-F).

505. Advanced Engineering Mathematics for Electrical Engineers (3)

Prerequisite: Consent of instructor.

Boundary–value problems and generalized Fourier (or eigenfunction) expansions. Review of Fourier series. Fourier transforms (FT, FFT and STFT), wavelet transform and its computer implementation. Z–transform. Hilbert transform. Solutions of partial differential equations using methods of separation of variables, etc.

(Lecture–problems 3 hours) Letter grade only (A-F).

506./606. Theory and Practice of Biomedical Instrumentation (3)

Prerequisites: Graduate standing in engineering or natural sciences and either EE 406 with a grade of "C" or better or consent of instructor.

Advanced design concepts and practical utilization of biomedical instrumentation. Transduction of physiological parameters. Theory and practice.

Master's students register in EE 506; Ph.D. students register in EE 606. Additional projects required for EE 606. (Lecture-problems 3 hours) Letter grade only (A-F).

507./607. Advanced Biomedical Systems (3)

Prerequisites: Graduate standing in engineering or natural sciences and either EE 406 with a grade of "C" or better or consent of instructor.

Novel trends in biotechnology, design and organization of modern hospital systems, and utilization of advanced technologies. Modeling and simulation of physiological and medical systems.

Master's students register in EE 507; Ph.D. students register in EE 607. Additional projects required for EE 607. (Lecture-problems 3 hours) Letter grade only (A-F).

508. Probability Theory and Random Processes (3)

Prerequisite: EE 380 with a grade of "C" or better.

Probability spaces, random vectors and processes, convergence concepts, stationarity and ergodic properties, second-order moments and linear systems, correlation and spectral representations. Some applications of random processes.

(Lecture-problems 3 hours) Letter grade only (A-F).

509. Network Theory (3)

Prerequisite: EE 386 or 410 or 430 all with a grade of "C" or better.

Network classifications and study of non-linear circuits. Analysis of linear networks using topological and state-space techniques. Characterization of networks using scattering and other parameters. Tellegen's theorem and its application.

(Lecture-problems 3 hours) Letter grade only (A-F).

510. Circuit Synthesis (3)

Corequisite: EE 509.

Synthesis of passive lumped networks, cascade synthesis (link with filter synthesis), realization of commensurate distributed networks, discrete passive networks.

(Lecture-problems 3 hours) Letter grade only (A-F).

511. Linear Systems Analysis (3)

Prerequisite: EE 411 or 470 all with a grade of "C" or better or equivalent mathematical maturity.

Review of linear algebra and z-transforms. Continuous and discrete-time systems. Sampled data systems. State-space linear system analysis. Stability, reachability, and observability. Minimal realization. State feedback and pole assignment. Asymptotic observers. Examples of applications. Project on a related subject.

(Lecture-problems 3 hours) Letter grade only (A-F).

514. Advanced Circuit Synthesis and Design (3)

Prerequisite: EE 510 with a grade of "C" or better.

Scattering synthesis in (s-z) domains, wave digital filters. Lossless bounded-real two-pair and orthogonal digital filters with an emphasis on structures suitable for VLSI implementation.

(Lecture-problems 3 hours) Letter grade only (A-F).

526. High Speed Communication Circuits (3)

Prerequisite: EE430 with a grade of "C" or better or consent of instructor

Design of integrated circuits for high speed data communication. Serial communication standards. Transceiver architecture. High speed and broadband circuit design techniques. Serializer, deserializer, clock recovery circuits. Channel equalization. Jitter and channel interference issues.

(Lecture-problems 3 hours) Letter grade only (A-F).

527./427. Digital Filter Design and Audio Processing (3)

Prerequisite: EE 386 with a grade of "C" or better or consent of instructor.

Digital filter design methods, filter architectures, round-off noise, implementation and applications to audio signal processing. Additional projects required for EE 527.

Not open for credit to students with credit in EE 513. (Lecture-problems 3 hours) Letter grade only (A-F).

528./428. Speech Signal Processing (3)

Prerequisite/Corequisite: EE 486 or consent of instructor.

Principles and engineering applications of speech signal processing. Speech synthesis, recognition, encoding, and compression. Applications of neural networks.

Additional projects required for EE 528. (Lecture-problems 3 hours) Letter grade only (A-F).

531. CMOS Electronics (3)

Prerequisite: EE 430 with a grade of "C" or better.

Electronic design automation CAD tools, silicon compilers, CMOS design, BiCMOS design (technologies, modeling, device characterization and simulation), CMOS and BiCMOS subcircuits, amplifiers, op-amps and systems.

(Lecture-problems 3 hours) Letter grade only (A-F).

532./632. Analog Signal Processing (3)

Prerequisite: EE 430 with a grade of "C" or better or consent of instructor.

Basic CMOS circuit techniques. Low-voltage and current-mode signal processing. Switched-capacitor (SC)and switched-current (SI) circuits such as amplifiers, integrators, S/H circuits, filters, oscillators, D/A and A/D converters, etc. Advanced techniques for corrections of nonideal behavior. Analysis and simulation projects.

Master's students register in EE 532; Ph.D. students register in EE 632. Additional projects required for EE 632. Letter grade only (A-F). (Lecture-problems 3 hours)

533./633. Quantum and Optical Electronics (3)

Prerequisite: EE 360 or 462 or 464 all with a grade of "C" or better or consent of instructor.

Modern quantum and optical concepts of relevance in lasers, fiber optics, optical technology and semiconductor solid state electronics. Basic theory and applications to state-of-the-art electronics engineering.

Master's students register in EE 533; Ph.D. students register in EE 633. Additional projects required for Ph.D. students. (Lecture-problems 3 hours) Letter grade only (A-F).

534./434. Mixed-Signal IC Design (3)

Prerequisites: (EE 201 and 330) all with a grade of "C" or better or consent of instructor.

CMOS fabrication. Component layout. MOSFET modeling. Mixed-signal devices such as D/A and A/D converters and phase-locked loops. Substrate Noise coupling. System-on-chip considerations. Design using CAD tools.

Additional projects required for EE 534. (Lecture-problems 2 hours, Laboratory 3 hours) Letter grade only (A-F).

535. VLSI Design (3)

Prerequisite: EE 430 with a grade of "C" or better.

Techniques for designing Very Large Scale Integrated (VLSI) circuits using n-channel metal oxide semiconductors (n-MOS).

Not open for credit to students with credit in EE 520. (Lecture-problems 3 hours) Letter grade only (A-F).

535A./435. Microelectronics (3)

Prerequisites: (EE 201 and 330) all with a grade of "C" or better or consent of instructor.

Theory of microelectronics integrated circuit design, IC fabrication technology, device characterization, modelling, digital and analog simulation tools, physical layout tools, digital standard cell library design, IC digital system designs, I/O pad design, full chip simulation and physical designs.

Letter grade only (A-F). Additional projects required for EE 535A. (Lecture-problems 3 hours)

536./436. Microfabrication and Nanotechnology (3)

Prerequisites: EE 330; EE 320 or PHYS 254; or MAE 300 all with a grade of "C" or better.

Techniques and technology of miniaturization of electrical, mechanical, optical, and opto-electronic devices in sizes from millimeters to nanometers are presented. Design examples of sensors, microlenses, cantilevers, and micromotors are covered and process fabrication using latest technology demonstrated.

Additional projects required for EE 536. (Lecture-problems 3 hours) Letter grade only (A-F).

540. Advanced Digital System and Computer Architecture (3)

Prerequisite: EE 446 with a grade of "C" or better or equivalent. Strongly recommended: EE 546.

High level computer architectures including studies of network processors, security processing, embedded computers; system design and implementation approaches including ASIC's, SOC's, and networks on chip concepts. Simulation and design tools. Project required.

(Lecture-problems 3 hours) Letter grade only (A-F).

545. Computer Communication Networks (3)

Prerequisite: Consent of instructor.

Design and analysis of computer communications networks including their topologies, architectures, protocols, and standards. LAN, WAN environments and access methods. Ethernet, ATM, bridges, routers, gateways and intelligent hubs. TCP/IP and other Networking protocols. Load balancing, traffic monitoring, use of simulation tools.

(Lecture-problems-computer projects 3 hours) Letter grade only (A-F).

546. Advanced Microprocessors and Embedded Controllers II (3)

Prerequisite: EE 446 with a grade of "C" or better or consent of the instructor.

Advanced concepts for embedded controllers, mobile processors, network processors, embedded Internet, and embedded Internet devices. Parallelism, multithreading, pipelining, coherence protocols, interconnection networks, clustering. Simulation and analysis tools. Project required.

(Lecture-problems 3 hours) Letter grade only (A-F).

548./448. Wireless and Mobile Networks and Security in Wireless Networks (3)

Prerequisites: EE 482 with a grade of "C" or better or equivalent.

Wireless and Mobile Ad-hoc Networks and Security. Ad-hoc and geographic routing, resource discovery, MAC, IP-mobility, mobility modelling, wired-wireless networks, security aspects. Lab Projects will include use of tools such as OPNET, Ethereal, Sniffer, Scanner, IDS, etc.

Advanced project required for EE 548. (Lecture-problems 3 hours) Letter grade only (A-F).

550. Power Electronics and Applications (3)

Prerequisites: EE 350 and 430 all with a grade of "C" or better.

Power converters: rectifiers, inverters, choppers and cycloconverters. PWM and PFM techniques. Harmonics and filters. Magnetics. Applications in motor controls in industrial systems, energy conversion, HVDC transmission, aircraft and spacecraft power systems.

(Lecture-problems 3 hours) Letter grade only (A-F).

551. Theory and Applications of DC/DC Converters (3)

Prerequisite: EE 550 with a grade of "C" or better or consent of instructor.

Modeling, analysis, design and application of DC/DC switch-mode converters.

(Lec-prob 3 hrs) Letter grade only (A-F).

552. Electric Drives and Applications (3)

Prerequisites: EE 370 and 452 all with a grade of "C" or better or consent of instructor.

Characteristics and applications of small electric machines including stepper motors, brushless DC motors, permanent-magnet synchronous motors and switched-reluctance motors. Motor performance, control and drive-circuit configurations.

(Lecture-problems 3 hours) Letter grade only (A-F).

553./453. Protection of Power Systems (3)

Prerequisites: EE 310 and 350 all with a grade of "C" or better.

Protective relays, instrument transformers, low-voltage and high-voltage circuit breakers, protection of generators and motors, transformer protection and transmission line protection. Relay coordination and commercial power systems. Application of computer programs for protective device coordination. Additional projects required for EE 553.

(Lecture-problems 3 hours) Letter grade only (A-F).

555./455. Space Electric Power Systems (3)

Prerequisites: EE 330 and 350 all with a grade of "C" or better.

A comprehensive treatment of characteristics of and requirements from spacecraft power systems, power sources, power conversion and control. Energy storage, electrical equipment, power converters and loads, power management. Future space missions and technological needs.

Additional projects required for EE 555. (Lecture-problems 3 hours) Letter grade only (A-F).

566. RF and Microwave Electronics (3)

Prerequisite: EE 360 or 462 or 464 all with a grade of "C" or better or consent of instructor.

Transmission Lines, Waveguides, Matching Networks, MW Amplifier Design, MW Resonators Design, MW Oscillator Design, MW Mixer, Noise Analysis in Microwave Electronics and Network Analysis Methods.

(Lecture-problems 2 hours, Laboratory 3 hours). Letter grade only (A-F).

574./474. Robot Modeling and Control (3)

Prerequisite: EE 370 with a grade of "C" or better. Recommended: EE 411 or 511.

Basic methodology for analysis and design of robotic manipulators. Classification of robots. Homogeneous transformations, kinematics, dynamics, trajectory planning and control of robots. Application of robots in flexible manufacturing. Advanced projects required for EE 574. EE 411 or 511 is recommended as a pre/corequisite.

(Lecture-problems 3 hours) Letter grade only (A-F).

575./675. Non-Linear Control Systems (3)

Prerequisite: EE 511 with a grade of "C" or better or consent of instructor.

Methodologies and results dealing with stability and robust stabilization of non-linear systems applied to robotics, aerospace, artificial neural networks, etc. Phase plane analysis, limit cycles, Lyapunov stability theory and its extension, Positive real transfer matrix and passivity, feedback linearization and stabilization, tracking, robust control.

Ph.D. students register in EE 675. Advanced projects for EE 675 students. (Lecture-problems 3 hours) Not open for credit to students with credit in EE 775. Letter grade only (A-F).

576./476. Neural Networks and Fuzzy Logic (3)

Prerequisite: EE 386 with a grade of "C" or better or consent of instructor

Principles and application of artificial neural networks and fuzzy logic. Mechanisms of supervised and unsupervised neural networks. Fuzzy control systems. Applications in signal processing, communications, control, and other areas.

Additional projects required for EE 576. Not open for credit to students with credit in EE 589/689. (Lecture-problems 3 hours) Letter grade only (A-F).

580. Statistical Communication Theory (3)

Prerequisites: (EE 482, 505 and 508) all with a grade of "C" or better or consent of instructor.

Power spectral density of analog and digital communication signals. Matched filters. Signal-to-noise-ratio performance analysis for analog and pulse modulation systems. Vector space representation of digital signals. Error rate analysis for various signaling formats. Optimum digital receivers. Fading channels.

(Lecture-problems 3 hours) Letter grade only (A-F).

581./481. Satellite Communication Systems (3)

Prerequisite: EE 482 with a grade of "C" or better.

Basic orbital mechanics, link analysis, multiple access architectures and protocols, FDMA, TDMA, and CDMA systems. Synchronization techniques, modulation and coding techniques. Security and spread spectrum requirements. System design.

Additional projects required for EE 581. (Lecture-problems 3 hours) Letter grade only (A-F).

582. Spread Spectrum Communication Systems (3)

Prerequisite: EE 580 with a grade of "C" or better or consent of instructor.

Spread spectrum (SS) techniques. Direct sequence systems, frequency hopped systems. Generation and properties of pseudo random sequences. Electronic jamming and interference. Processing gain, carrier synchronization, code acquisition and tracking, information modulation and coding. Applications include ranging, CDMA etc.

(Lecture-problems 3 hours) Letter grade only (A-F).

583./683. Digital Image Processing (3)

Prerequisite: EE 505 with a grade of "C" or better or consent of instructor.

Acquiring Images. Correcting Imaging defects. Image enhancement. Segmentation and threshholding. Processing Binary images. Tomography. Three dimensional Imaging. Some image data compression techniques.

Masters students register in EE 583; Ph.D. students register in EE 683. Additional projects required for EE 683. (Lecture–problems 3 hours) Letter grade only (A-F).

584. Information Theory and Coding (3)

Prerequisites: EE 482 and 508 all with a grade of "C" or better.

Information measures, source coding, Shannon's first theorem, mutual information and channel capacity, Shannon's second theorem, coding techniques for reliable information transmission over noisy channels.

(Lecture-problems 3 hours) Letter grade only (A-F).

585./685. Advanced Digital Signal Processing (3)

Prerequisite: EE 486 with a grade of "C" or better or consent of the instructor.

Advanced topics in digital signal processing and applications to communication and power line systems, including adaptive filters, FFT-based OFDM transceivers. IEEE standards for green energy communication and optimization.

Masters students register in EE 585; Ph.D. students register in EE685. Additional projects for EE 685. (Lecture-problems 3 hours). Letter grade only (A-F).

586. Real–Time Digital Signal Processing (3)

Prerequisite: EE 486 or CECS 440 all with a grade of "C" or better or consent of instructor.

Digital signal processors architecture and language. Real–time DSP considerations and limitations. Digital filter and signal processing system implementations.

(Lecture–problems 3 hours) Letter grade only (A-F).

590. Selected Topics in Electrical Engineering (3)

Prerequisites: Graduate standing in electrical engineering and consent of instructor.

Selected topics from recent advances in electrical engineering.

Letter grade only (A-F). May be repeated to a maximum of 6 units. Topics announced in the *Schedule of Classes*. (Lecture-problems 3 hours)

591. Adaptive Systems (3)

Prerequisite: EE 508 with a grade of "C" or better.

Adaptive systems and their applications to communication, control, and signal processing systems.

(Lecture-problems 3 hours) Letter grade only (A-F).

600. Graduate Seminar and Presentation (1)

Prerequisites: Graduate standing and advancement to candidacy.

Lectures by faculty and guests on advanced topics. A report and presentation are required.

(Seminar 1 hour) Letter grade only (A-F).

606./506. Theory and Practice of Biomedical Instrumentation (3)

Prerequisites: Graduate standing in engineering or natural sciences; and either EE 406 with a grade of "C" or better or consent of instructor.

Advanced design concepts and practical utilization of biomedical instrumentation. Transduction of physiological parameters. Theory and practice.

Master's students register in EE 506; Ph.D. students register in EE 606. Additional projects required for EE 606. (Lecture-problems 3 hours) Letter grade only (A-F).

607./507. Advanced Biomedical Systems (3)

Prerequisites: Graduate standing in engineering or natural sciences; and either EE 406 with a grade of "C" or better or consent of instructor.

Novel trends in biotechnology, design and organization of modern hospital systems and utilization of advanced technologies. Modeling an simulation of physiological and medical systems.

Master's students register in EE 507; Ph.D. students register in EE 607. Additional projects required for EE 607. (Lecture-problems 3 hours) Letter grade only (A-F).

632./532. Analog Signal Processing (3)

Prerequisite: EE 430 with a grade of "C" or better or consent of instructor.

Basic CMOS circuit techniques. Low-voltage and current-mode signal processing. Switched-capacitor (SC)and switched-current (SI) circuits such as amplifiers, integrators, S/H circuits, filters, oscillators, D/A and A/D converters, etc. Advanced techniques for corrections of nonideal behavior. Analysis and simulation projects.

Master's students register in EE 532; Ph.D. students register in EE 632. Additional projects required for EE 632. Letter grade only (A-F). (Lecture-problems 3 hours).

633./533. Quantum and Optical Electronics (3)

Prerequisite: EE 360 or 462 or 464 all with a grade of "C" or better or consent of instructor.

Modern quantum and optical concepts of relevance in lasers, fiber optics, optical technology and semiconductor solid state electronics. Basic theory and applications to state-of-the-art electronics engineering.

Master's students register in EE 533; Ph.D. students register in EE 633. Additional projects required for Ph.D. students. (Lecture-problems 3 hours) Letter grade only (A-F).

675./575. Non-Linear Control Systems (3)

Prerequisite: EE 511 with a grade of "C" or better or consent of instructor.

Methodologies and results dealing with stability and robust stabilization of non-linear systems applied to robotics, aerospace, artificial neural networks, etc. Phase plane analysis, limit cycles, Lyapunov stability theory and its extension, Positive real transfer matrix and passivity, feedback linearization and stabilization, tracking, robust control.

Ph.D. students register in EE 675. Advanced projects for EE 675 students. (Lecture-problems 3 hours) Not open for credit to students with credit in EE 775. Letter grade only (A-F).

683./583. Digital Image Processing (3)

Prerequisite: EE 505 with a grade of "C" or better or consent of instructor.

Acquiring Images. Correcting Imaging defects. Image enhancement. Segmentation and threshholding. Processing Binary images. Tomography. Three dimensional Imaging. Some image data compression techniques.

Masters students register in EE 583; Ph.D. students register in EE 683. Additional projects required for EE 683. (Lecture–problems 3 hours) Letter grade only (A-F).

685./585. Advanced Digital Signal Processing (3)

Prerequisite: EE 486 with a grade of "C" or better or consent of the instructor.

Advanced topics in digital signal processing and applications to communication and power line systems, including adaptive filters, FFT-based OFDM transceivers. IEEE standards for green energy communication and optimization.

Masters students register in EE 585; Ph.D. students register in EE 685. Additional projects for EE 685. (Lecture-problems 3 hours) Letter grade only (A-F).

697. Directed Research (3)

Prerequisite: Graduate Standing. Advancement to Candidacy is strongly recommended.

Theoretical and experimental problems in electrical engineering requiring intensive analysis culminating in a substantial report.

Letter grade only (A-F).

698. Thesis or Industrial Project (3-6)

Prerequisite: Advancement to Candidacy.

Planning, preparation and completion of a thesis (total 6 units), or industrial project (3 units), in electrical engineering.

Letter grade only (A-F).