COMPUTER ENGINEERING BSCE

Computer Engineering

College of Science, Engineering & Technology
Department of Electrical and Computer Engineering and Technology
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Accreditation. The Computer Engineering program is accredited by the Engineering Accreditation Commission of ABET, www.abet.org.

Computer Engineering (CE) encompasses the research, development, design and operation of computers and computerized systems and their hardware and software components. This program leads to a Bachelor of Science in Computer Engineering. The primary objective of the Computer Engineering program is to educate engineering professionals who possess sound design and analytical background coupled with a strong laboratory experience supporting Computer Engineering concepts. This means that the department prepares its graduates for:

1. Entry into the engineering work environment with well-developed design and laboratory skills.
2. Further study toward advanced degrees in engineering and other related disciplines.
3. Advancement into managerial ranks and/or entrepreneurial endeavors.

The educational objectives for our Bachelor of Science in Computer Engineering degree are:

1. Graduates who receive the B.S.C.E. (Graduates) will function as responsible members of society with an awareness of the social, ethical, and economic ramifications of their work.
2. Graduates will become successful practitioners in engineering and other diverse careers.
3. Graduates will succeed in full time graduate and professional studies.
4. Graduates will pursue continuing and life-long learning opportunities.
5. Graduates will pursue professional registration.
6. Graduates will gain foundational education that allows for personal growth and flexibility throughout their career.

Our metrics for determining success in meeting these objectives will include:

1. Assessment of societal, economic awareness, and ethical performance of our graduates by the graduate and employer.
2. Monitoring of the success of our graduates in the work force.
3. Monitoring of the success of our graduates in graduate and professional programs.
4. Assessment of continuing and life-long learning by the graduate (and their employer as applicable.).
5. Reviewing the number and success of our students completing professional registration to advance their careers.

In support of these objectives, the program provides a curriculum including the following components that will prepare students for excellent careers in Computer Engineering

1. A strong background in the physical sciences; mathematics, including discrete math; and engineering sciences, including extensive hands-on laboratory instruction.
2. An integrated design component including instruction in basic practices and procedures, creativity, control, economics, and synthesis. The process begins with basic instruction during the first year and concludes with a capstone design project.
3. A choice of sub-disciplines such as Internet of Things (IoTs), Application Specific Integrated Circuits (ASICs), in the junior/senior level electives.
4. Opportunities for students to develop sensitivity to the social and humanistic implications of technology and motivate them to make worthwhile contributions to the profession and society, while upholding the highest standards of professional ethics.
5. A course in engineering economics to promote awareness of the economic aspects of engineering.
6. Preparation for continuing study and professional development.

During the senior year, as allowed by the state, students are strongly recommended to take the Fundamentals of Engineering (FE) examination or its equivalent. The curriculum offers students the opportunity to emphasize a number of specialized areas including advanced digital systems, communications, digital signal processing, networking and system design.

The recommended high school preparation is two years of algebra, one year of geometry, one-half year of trigonometry, one-half year of college algebra, and a year each of physics and chemistry plus a programming language. Without this background it may take students longer than four years to earn a degree. During the first two years students take physics and mathematics courses common to all branches of engineering (pre-engineering), two programming language courses, a discrete mathematics course (specifically designed for computer engineers), as well as supporting work in English, humanities, and social sciences. Second-year computer engineering students complete physics, mathematics and 200-level engineering and object-oriented design and software development courses.

All international students wishing to have transfer credits granted from non-U.S. schools will be required to use the ECE evaluation service to be completed no later than first semester at Minnesota State Mankato.

Academic Map/Degree Plan at www.mnsu.edu/programs/#All

POLICIES/INFORMATION

Admission to Major. Admission to the college is necessary before enrolling in 300- and 400-level courses. Minimum college requirements are:

- A minimum of 32 earned semester credit hours.
- A minimum cumulative GPA of 2.00 ("C").

Please contact the department for application procedures.

During the spring semester of the sophomore year, students should submit an application form for admission to the Computer Engineering program. Admission to the program is selective and, following applications to the department, subject to approval from the department chair. The department makes a special effort to accommodate transfer students. Only students admitted to the program are permitted to enroll in upper-division electrical engineering courses. No transfer credits are allowed for upper-division engineering courses except by department chair review and approval.

Before being accepted into the program and admitted to 300-level engineering courses (typically in the fall semester), a student must complete the following courses including all necessary prerequisites:

- General Physics I and II (calculus-based) (8 credits)
- Calculus I, Calculus II and Differential Equations (12 credits)
- Introduction to Electrical/Computer Engineering I and II (6 credits)
- Circuit Analysis I and II (including lab) (7 credits)
- English Composition (4 credits)
- Technical Communication (4 credits)
- Microprocessor course and lab (4 credits)

A cumulative GPA of 2.5 for all science and math courses must have been achieved for program admittance. Grades must be 1.65 ("C-") or better for courses to be accepted.

GPA Policy. Students graduating with a degree in Computer Engineering must have:

- completed a minimum of 20 semester credit hours of upper division EE and CS courses at Minnesota State Mankato.
- have a cumulative GPA of 2.25 on all upper division EE and CS courses, and
- have completed their senior design sequence at Minnesota State Mankato.

GPA. A cumulative grade-point average of 2.5 for all science, math and engineering courses must have been maintained. Grades must be 1.65 "C-" or better for course to be accepted. Minnesota State Mankato students should complete the pre-engineering courses listed under the major.

Petition to evaluate transfer credits must occur no later than the first semester the student is enrolled in or declared a major housed in the Department of Electrical and Computer Engineering Technology.

P/N Grading Policy. A student who majors in CE must elect the grade option for all required courses including courses offered by another department.

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Degree completion = 128 credits

Required General Education

ENG	101	Composition (4)
ENG	271W	Technical Communication (4)
MATH	121	Calculus I (4)
PHYS	221	General Physics I (4)

Economics (choose 3 credits)

ECON	201	Principles of Macroeconomics (3)
ECON	202	Principles of Microeconomics (3)

Prerequisites to the Major

EE	106	Fundamental Digital System Design for Electrical and Computer Engineers (3)
EE	107	Intro to Electrical and Computer Engineering Through Software Development (3)
EE	230	Circuit Analysis I (3)
EE	231	Circuit Analysis II (3)
EE	234	Microprocessor Engineering I (3)
EE	235	Microprocessor Engineering Laboratory I (1)
EE	240	Evaluation of Circuits (1)
MATH	122	Calculus II (4)
MATH	321	Ordinary Differential Equations (4)
PHYS	222	General Physics II (3)
PHYS	232	General Physics II Laboratory (1)

Major Common Core

CS	460	Operating Systems: Design and Implementation (3)
EE	281	Digital System Design with Testability (3)
EE	282	Digital System Design with Testability Lab (1)
EE	332	Electronics I (3)
EE	334	Microprocessor Engineering II (3)
EE	336	Principles of Engineering Design I (1)
EE	337	Principles of Engineering Design II (1)
EE	341	Signals & Systems (3)
EE	342	Electronics Laboratory (1)
EE	344	Microprocessor II Laboratory (1)
EE	358	Control Systems (3)
EE	368	Control Systems Laboratory (1)
EE	395	Computer Hardware and Organization (3)
EE	450	Engineering Economics (3)
EE	467W	Principles of Engineering Design III (1)
EE	477W	Principles of Engineering Design IV (1)
IT	214	Fundamentals of Software Development (4)
IT	310	Data Structures & Algorithms (4)
MATH	180	Mathematics for Computer Science (4)
MATH	223	Calculus III (4)
ME	299	Thermal Analysis (2)
PHYS	223	General Physics III (3)
PHYS	233	General Physics III Laboratory (1)

Major Restricted Electives

Choose 14 credits: choose EE 333 (3) and then EE 333 (3) and then choose additional 11 credits e.g. CS 350, EE 481, EE 484, EE 485; or choose EE 390 (4) and then choose additional 10 credits e.g. CS 350, EE 470, and EE 489.

CS	350	Network Architectures (3)
EE	333	Electronics II (3)
EE	390	Smart Sensor Systems (4)
EE	453	Advanced Communications Systems Engineering (3)
EE	470	Wireless Networking (3)
EE	471	Advanced Control Systems (3)
EE	472	Digital Signal Processing (3)
EE	473	Electrical Power Systems Analysis and Design (3)
EE	474	Power Electronics (4)
EE	475	Integrated Circuit Engineering (3)
EE	476	Antennas, Propagation, & Microwave Engineering (3)
EE	479	Superconductive Devices (3)
EE	480	Integrated Circuit Fabrication Lab (1)
EE	481	VLSI Design Laboratory (1)
EE	484	VLSI Design (3)
EE	485	ASIC Design (4)
EE	487	RF Systems Engineering (3)
EE	489	Real-time Embedded Systems (4)

Other Graduation Requirements

Choose a minimum of twelve (12) credits of Humanities (6 credits) and Social Sciences (6 credits). For example, ECON 201 is a Social Sciences course. For a complete listing of approved Humanities and Social Science courses please consult the department website. In general, graduation credits toward the humanities requirement is not allowed for any course in subject areas such as communication studies, writing, art, music or theatre that involve performance or practice of basic skills. At least three (3) credits of the courses selected to complete the above requirements must be 300-level or above. At least one 300-level course must follow a lower level course in the same subject area.

Analysis/Probability and Statistics (choose 3 credits)

MATH	354	Concepts of Probability & Statistics (3)
ME	291	Engineering Analysis (3)

Required Minor: None.

COURSE DESCRIPTIONS

Computer Information Technology Courses

IT 214 (4) Fundamentals of Software Development
A continuation of IT 210, IT 214 introduces object-oriented concepts, programming techniques, lists, stacks, queues, and trees. Students are expected to produce larger applications, utilizing multiple compilation units.
Prerequisite: (EE 107 or IT 210) and (MATH 113 or MATH 115 or MATH 121 or MATH 180)
Fall, Spring

IT 310 (4) Data Structures & Algorithms
Study of trees, hashing, and graph algorithms. Analysis of algorithms, memory management, and proof techniques.
Prerequisite: IT 214
Variable

Computer Science Courses

CS 350 (3) Network Architectures
An introduction to data communications and networks. The field encompasses local area networks, wide area networks, and wireless communication. Topics include digital signals, transmission techniques, error detection and correction, OSI model, TCP/IP model, network topologies, network protocols, and communications hardware.
Prerequisite: CS 305 or EE 234
Spring

CS 460 (3) Operating Systems: Design & Implementation
This course studies historical and current concepts and implementations of computer operating systems. Basic operating systems topics include processes, interprocess communication, interprocess synchronization, deadlock, memory allocation, segmentation, paging, resource allocation, scheduling, file systems, storage, devices, protection, security, and privacy.
Prerequisite: CS 210 and CS 320
Spring

Electrical Engineering Courses

EE 100 (1) Explorations in Engineering
This course offers an introduction to the various disciplines of engineering and their relationship to the principles of physics and mathematics. Students are prepared for academic success and the transition into an engineering program.
Fall
GE-12

EE 106 (3) Fundamental Digital System Design for Electrical and Computer Engineers
This introductory course covers digital systems topics including binary numbers, logic gates, Boolean algebra, circuit simplification using Karnaugh maps, flip-flops, counters, shift registers and arithmetic circuits. Problem solving methods, study skills and professional development will be addressed throughout the course.
Prerequisite: MATH 112
Fall Spring

EE 107 (3) Intro to Electrical and Computer Engineering Through Software Development
The course presents algorithmic approaches to problem solving and computer program design using the C language. Student will explore Boolean expressions, implement programs using control structures, modular code and file input/output, and interface with external hardware using robots and sensors.
Prerequisite: EE 106 or concurrent
Spring

EE 230 (3) Circuit Analysis I
This course is meant to develop Electrical Engineering Circuit Analysis skills in DC and AC circuits. It includes circuit laws and theorems, mesh and node analysis. Natural and step response of RL, RC, and RLC circuits.
Prerequisite: PHYS 222 or concurrent, MATH 321 or concurrent
Fall

EE 231 (3) Circuit Analysis II
Continuation of Circuit Analysis I to include special topics in circuit analysis.
Prerequisite: EE 230 and EE 240, MATH 321, PHYS 222
Spring

EE 234 (3) Microprocessor Engineering I
A course that teaches how to write computer assembly language programs, make subroutine calls, perform I/O operations, handle interrupts and resets, interface with a wide variety of peripheral chips to meet the requirements of applications.
Prerequisite: EE 106, EE 107
Corequisite: EE 235
Fall

EE 235 (1) Microprocessor Engineering Laboratory I
Use of development boards and assembly language programming to handle interrupts, interface with parallel I/O ports, memory, and timers. Experiments will involve signal and frequency measurements, data conversions, and interface design.
Prerequisite: EE 106, EE 107
Corequisite: EE 234

EE 240 (1) Evaluation of Circuits
Laboratory support for EE 230. Use of laboratory instrumentation to measure currents and voltages associated with DC and AC circuits. Statistical analysis of measurement data. Measurements of series, parallel and series-parallel DC and AC circuits. Measurement of properties for circuits using operational amplifiers. Measurement of transient responses for R-L and R-C circuits. Simulation of DC and AC circuits using PSPICE. Concepts covered in EE 230 will be verified in the laboratory.
Prerequisite: Must be taken concurrently with EE 230.
Fall

EE 244 (2) Introduction to Digital Systems
Simple coding schemes, Boolean algebra fundamentals, elements of digital building blocks such as gates, flip-flops, shift registers, memories, etc.; basic engineering aspects of computer architecture.

EE 253 (1) Logic Circuits Lab
Laboratory support to complement EE 244. Use of laboratory instrumentation to measure characteristics of various logic circuits and digital subsystems. Experimental evaluation of digital logic devices and circuits including logic gates, flip-flops, and sequential machines.
Prerequisite: EE 230 and concurrent with EE 244.
Spring

EE 254 (1) Digital and Circuits Lab
Laboratory support for EE 231 and EE 244. Experimental evaluation of AC and transient circuits, digital logic devices including logic gates, flip flops, and sequential machines.
Prerequisite: EE 230, EE 240 and concurrently with EE 231 and EE 244
Spring

EE 281 (3) Digital System Design with Testability
Introduction to representing digital hardware using a hardware description language. Introduction to implementation technologies such as PAL's, PLA'S, FPGA's and Memories. Analysis, synthesis and design of sequential machines; synchronous, pulse mode, asynchronous and incompletely specified logic.
Prerequisite: EE 106, EE 107
Variable

EE 282 (1) Digital System Design with Testability Lab
Laboratory support for EE 282 practical aspects of design and analysis of different types of sequential machines will be presented through laboratory experience.
Corequisite: EE 281

EE 298 (1-4) Topics
Varied topics in Electrical and Computer Engineering. May be repeated as topics change.
Prerequisite: to be determined by course topic

EE 303 (3) Introduction to Solid State Devices
Introduction to crystal structure, energy band theory, conduction and optical phenomenon in semiconductors, metals and insulators. Study of equilibrium and non-equilibrium charge distribution, generation, injection, and recombination. Analysis and design of PN-junctions, (bipolar transistor, junction) and MOS field-effect transistors. Introduction to transferred electron devices and semiconductor diode laser.
Prerequisite: PHYS 222, and MATH 321
Fall

EE 304 (1) Lab: Introduction to Solid State Devices
Laboratory support for EE 303. Experiments include resistivity and sheet resistance measurements of semiconductor material, probing material, probing of IC chips, PN-junction IV and CV measurements, BJT testing to extract its parameters, MOSFET testing and evaluating its parameters, cv-measurements of MOS structure, and familiarization with surface analysis tools.
Fall

EE 332 (3) Electronics I
Introduction to discrete and microelectronics circuits including analog and digital electronics. Device characteristics including diodes, BJT's, JFET's, and MOSFET's will be studied. DC bias circuits, small and large signal SPICE modeling and analysis and amplifier design and analysis will be discussed.
Prerequisite: EE 231

EE 333 (3) Electronics II
The second course of the electronics sequence presenting concepts of feedback, oscillators, filters, amplifiers, operational amplifiers, hysteresis, bi-stability, and non-linear functional circuits. MOS and bipolar digital electronic circuits, memory, electronic noise, and power switching devices will be studied.
Prerequisite: EE 332
Spring

EE 334 (3) Microprocessor Engineering II
A more advanced study of microprocessors and microcontrollers in embedded system design. Use of C language in programming, interrupt interfaces such as SPI, I2C, and CAN. External memory design and on-chip program memory protection are also studied.
Fall

EE 336 (1) Principles of Engineering Design I
Electrical and computer engineering project and program management and evaluation techniques will be studied. Emphasis will be placed on the use of appropriate tools for planning, evaluation, and reporting on electrical and computer engineering projects.
Prerequisite: Junior Standing
Fall

EE 337 (1) Principles of Engineering Design II
Application of the design techniques in the engineering profession. Electrical engineering project and program management and evaluation including computer assisted tools for planning and reporting, design-to-specification techniques and economic constraints.
Prerequisite: EE 336
Spring

EE 341 (3) Signals & Systems
Analysis of linear systems and signals in the time and frequency domain. Laplace and Fourier transforms. Z-transform and discrete Fourier transforms.
Prerequisite: EE 230. MATH 321 and PHYS 222
Fall

EE 342 (1) Electronics Laboratory
This lab is designed to accompany EE 332. The lab covers the experimental measurement and evaluation of diode, BJT, and MOS characteristics; various feedback topologies; oscillator and op-amp circuits; and rectifiers and filter circuitry.
Prerequisite: EE 231 and EE 332 taken concurrently.
Fall

EE 344 (1) Design & Evaluation of Microprocessors
Laboratory support for EE 334. Use of development boards and C Programming language to handle I/O devices, interrupts, and all peripheral functions. Multiple functions such as timers, A/D converters, I/O devices, interrupts, and serial modules will be used together to perform desired operations.
Prerequisite: Concurrent with EE 334
Fall

EE 350 (3) Engineering Electromagnetics
Vector fields. Electrostatic charges, potential and fields; displacement. Steady current/current density; magnetostatic fields, flux density. Materials properties. Faraday's Law and Maxwell's equations. Skin effect. Wave propagation, plane waves, guided waves. Radiation and antennas. Transmission line theory.
Prerequisite: EE 231, MATH 223, MATH 321 and PHYS 222
Spring

EE 353 (3) Communications Systems Engineering
Signals and Systems, Fourier transforms, Parseval's theorem. Autocorrelation functions and spectral density functions. Information theory. Noise and noise figure, probability and statistics. Transformation of random variables, probability of error and bit error rate. Modulation and demodulation. Overview of analog, sampled analog and digital communication systems. Spread spectrum systems.
Prerequisite: EE 341, MATH 223
Spring

EE 358 (3) Control Systems
Theory and principles of linear feedback control systems. Analysis of linear control systems using conventional techniques like block diagrams, Bode plots, Nyquist plots and root-locus plots. Introduction to cascade compensation: proportional, derivative and integral compensation. State space models.
Prerequisite: EE 341
Spring

EE 363 (1) Communication Systems Laboratory
Measurement techniques using the oscilloscope, spectrum analyzer and network analyzer. Signals and spectra. Frequency response. Noise and noise figure measurements. Intermodulation products. Amplitude and frequency modulation/demodulation. Sampling, aliasing, and intersymbol interference. Bit error measurement.
Prerequisite: Concurrent with EE 353
Spring

EE 368 (1) Control Systems Laboratory
Laboratory support for EE 358. Experimental evaluation of basic control system concepts including transient response and steady state performance. Analog and digital computers.
Prerequisite: EE 341 and concurrent with EE 358
Spring

EE 390 (4) Smart Sensor Systems
This course explains the interfacing method between a sensor and the microcontroller, describes the features and functions of several frequently used sensors, it then proceeds to explore the subject of sensor fusion, describe the algorithms how multiple sensors are used to extract correct and more useful information than each individual single sensor; finally the course also explores how a large number of sensor nodes are connected together via the wireless or wired networking technology using one of the few possible topologies to enable the monitoring and control of our environment to improve our life.
Prerequisite: EE334 & EE344
Spring

EE 395 (3) Computer Hardware and Organization
High-level language constructs using a selected assembly language, design alternatives of computer processor datapath and control, memory hierarchy/management unit, use of HDL in describing and verifying combinational and sequential circuits. Design of computer processor and memory system.
Prerequisite: EE 234, EE 235, EE 281
Spring

EE 398 (0) CPT: Co-Operative Experience
Curricular Practical Training: Co-Operative Experience is a zero-credit full-time practical training experience for one summer and on adjacent fall or spring term. Special rules apply to preserve full-time student status. Please contact an advisor in your program for complete information.
Prerequisite: EE 235. At least 60 credits earned; in good standing; instructor permission; co-op contract; other prerequisites may also apply.
Fall, Spring, Summer

EE 450 (3) Engineering Economics
Overview of accounting and finance and their interactions with engineering. Lectures include the development and analysis of financial statements, time value of money, decision making tools, cost of capital, depreciation, project analysis and payback, replacement analysis, and other engineering decision making tools.
Prerequisite: Advanced standing in the program
Fall

EE 453 (3) Advanced Communications Systems Engineering
Behavior of analog systems and digital systems in the presence of noise, principles of digital data transmission, baseband digital modulation, baseband demondulation/detection, bandpass mondulation and demodulation of digital signals. Channel coding, modulation and coding trade-offs, spread spectrum techniques, probability and information theory.
Prerequisite: EE 353 and EE 363
Fall

EE 463 (3) Advanced Digital System Design
Design of combinational and sequential systems and peripheral interfaces. Design techniques using MSI and LSI components in an algorithmic state machine; implementation will be stresses. Rigorous timing analysis transmission-line effects and metastability of digital systems will be studied.
Prerequisite: EE 244

EE 467W (1) Principles of Engineering Design III
The design and organization of engineering projects. Project proposals, reporting, feasibility studies, and interpretation. Specification preparation, interpretation, and control. Issues involving creativity, project planning and control, and intellectual property rights. Students enrolled in this course must initiate and complete a design project in a small team format.
Prerequisite: EE 337 and senior standing
Fall
WI

EE 471 (3) Advanced Control Systems
This course is a continuation of EE 358. Techniques for the analysis of continuous and discrete systems are developed. These techniques include pole placement, state estimation, and optimal control.
Prerequisite: EE 358 and EE 368
Fall

EE 472 (3) Digital Signal Processing
Develop design and analysis techniques for discrete signals and systems via Z-transforms, Discrete Fourier Transforms, implementation of FIR and IIR filters. The various concepts will be introduced by the use of general and special purpose hardware and software for digital signal processing.
Prerequisite: EE 341
Spring

EE 473 (3) Electrical Power Systems Analysis and Design
Power generation, transmission and consumption concepts, electrical grid modeling, transmission line modeling, electric network power flow and stability, fault tolerance and fault recovery, economic dispatch, synchronous machines, renewable energy sources and grid interfacing.
Prerequisite: EE 231 or via permission from instructor
Variable

EE 474 (4) Power Electronics
This course is designed to provide students with knowledge of the design and analysis of static power conversion and control systems. The course will cover the electrical characteristics and properties of power semiconductor switching devices, converter power circuit topologies, and the control techniques used in the applications of power electronic systems. Laboratories consist of computer-based modeling and simulation exercises, as well as hands-on laboratory experiments on basic converter circuits and control schemes.
Prerequisite: EE 333
Spring

EE 475 (3) Integrated Circuit Engineering
Introduction to theory and techniques of integrated circuit fabrication processes, oxidation, photolithography, etching, diffusion of impurities, ion implantation, epitaxy, metallization, material characterization techniques, and VLSI process integration, their design and simulation by SUPREM.
Prerequisite: EE 303 and EE 332
Fall

EE 476 (3) Antennas, Propagation, & Microwave Engineering
Principles of electromagnetic radiation, antenna parameters, dipoles, antenna arrays, long wire antennas, Microwave antennas, Mechanisms of radiowave propagation, scattering by rain, sea water propagation, guided wave propagation, periodic structures, transmission lines, microwave/millimeter wave amplifiers and oscillators, MIC & MMIC technology.
Prerequisite: EE 350
Variable

EE 477W (1) Principles of Engineering Design IV
Completion of design projects and reports. Lectures on ethics, issues in contracting and liability, concurrent engineering, ergonomics and environmental issues, economics and manufacturability, reliability and product lifetimes. Lectures by faculty and practicing engineers.
Prerequisite: EE 467 and Senior Standing
Spring
WI

EE 479 (3) Superconductive Devices
Magnetic and superconducting properties of materials, microscopic theory of superconductivity and tunneling phenomenon. Josephson and SQUID devices, survey of computer memories, memory cell and shift register, A/D converters and microwave amplifiers. Integrated circuit technology and high temperature superconductors.
Prerequisite: EE 303
Variable

EE 480 (1) Integrated Circuit Fabrication Lab
Introduction to integrated circuit fabrication processes, device layout, mask design, and experiments related to wafer cleaning, etching, thermal oxidation, thermal diffusion, photolithography, and metallization. Fabrication of basic integrated circuit elements pn junction, resistors, MOS capacitors, BJT and MOSFET in integrated form. Use of analytic tools for in process characterization and simulation of the fabrication process by SUPREM.
Prerequisite: Concurrent with EE 475
Fall

EE 481 (1) VLSI Design Laboratory
This laboratory accompanies EE 484. The laboratory covers the basics of layout rules, chip floor planning, the structure of standard cells and hierarchical design, parasitic elements, routing, and loading. Students will learn to design and layout standard cells as well as how to use these cells to produce complex circuits. The laboratory culminates with the individual design and layout of a circuit.
Prerequisite: Concurrent with EE 484
Spring

EE 482 (3) Electromechanics
Electrical power and magnetic circuit concepts, switch-mode converters, mechanical electromechanical energy conversion, DC motor drives, feedback controllers, AC machines and space vectors, permanent magnet AC machines and drives, induction motors and speed control of induction motors, stepper motors.
Prerequisite: EE 230
Fall

EE 484 (3) VLSI Design
The basics of digital VLSI technology. Bipolar and MOS modeling for digital circuits. Physical transistor layout structure and IC process flow and design rules. Custom CMOS/BICMOS static and dynamic logic styles, design and analysis. Clock generation, acquisition, and synchronization procedures. Special purpose digital structures including memory, Schmitt triggers, and oscillators. Individual design projects assigned.
Prerequisite: EE 333
Fakk

EE 485 (4) ASIC Design
This course focuses on CMOS Application Specific Integrated Circuit (ASIC) design of Very Large Scale Integration (VLSI) systems. The student will gain an understanding of issues and tools related to ASIC design and implementation. The coverage will include ASIC physical design flow, including logic synthesis, timing, floor-planning, placement, clock tree synthesis, routing and verification. An emphasis will be placed on low power optimization. The focus in this course will be Register-transfer level (RTL) abstraction using industry-standard VHDL/Verilog tools.
Prerequisite: EE 484
Spring

EE 487 (3) RF Systems Engineering
Overview of wireless communication and control systems. Characterization and measurements of two-port RF/IF networks. Transmission lines. Smith chart. Scattering parameters. Antenna-preselector-preamplifier interface. Radio wave propagation. Fading. RF transistor amplifiers, oscillators, and mixer/modulator circuits. Multiple access techniques. Transmitter/receiver design considerations. SAW matched filters.
Prerequisite: EE 353 and EE 363
Variable

EE 489 (4) Real-time Embedded Systems
This course introduces students the recent advances in real-time embedded systems design. Topics cover real-time scheduling approaches such as clock-driven scheduling and static and dynamic priority driven scheduling, resource handling, timing analysis, inter-task communication and synchronization, real-time operating systems (RTOS), hard and soft real-time systems, distributed real-time systems, concepts and software tools involved in the modeling, design, analysis and verification of real-time systems.
Prerequisite: EE 107, EE 334, EE 395
Variable

EE 491 (1-4) In-Service

EE 494 (1) Global Experience in Engineering and Technology
This class provides students pursuing a minor in "Global Solutions in Engineering and Technology" with an opportunity to explore a set of topics related to achieving success in advance of and following an international experience (internship, study abroad, etc.). Speakers will include faculty, graduate students, visiting researchers and industry members as well as student participants. Returning students will be required to participate in mentoring of students preparing for their international experience and provide written and/or oral presentations of various topics during the semester. This course is required both before and after participation in the international experience (min. 2 cr.)
Variable

EE 497 (1-6) Internship

EE 498 (1-4) Topics
Varied topics in Electrical and Computer Engineering. May be repeated as topics change.
Prerequisite: to be determined by course topic

EE 499 (1-6) Individual Study