Electrical Engineering  

College of Science, Engineering and Technology  
Department of Electrical & Computer Engineering and Technology  
242 Trafton Science Center N • 507-389-5747  
Website: www.cset.mnsu.edu/ect

Chair: Gale Allen, Ph.D.  
Program Coordinator: Julio Mandojana, Ph.D.

Gale Allen, Ph.D.; Tom Hendrickson, Ph.D.; Han-Way Huang, Ph.D.; Rajiv Kappadia, Ph.D.; Muhammad Khaliq, Ph.D.; Julio Mandojana, Ph.D.; Ramakrishna Nair, Ph.D.; Vincent Winstead, Ph.D., P.E.; Qun Zhang, Ph.D.

Electrical Engineering (EE) encompasses research, development, design and operation of electrical and electronic systems and their components. This program leads to a Bachelor of Science in Electrical Engineering (BSEE). The primary objective of the Electrical Engineering program is to educate engineering professionals who possess a sound design and analytical background coupled with a strong laboratory experience. This means that the department prepares its Electrical Engineering 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 Electrical Engineering degree are to prepare our graduates to:

1. Function as responsible members of society with an awareness of the social, ethical, and economic ramifications of their work.
2. Become successful practitioners in engineering and other diverse careers.
3. Succeed in full time graduate and professional studies.
4. Pursue continuing and life-long learning opportunities.
5. Pursue professional registration.
6. Provide foundational education that allows for personal growth and flexibility through 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.

The Electrical Engineering degree curriculum includes the following components:

1. A strong background in the physical sciences, mathematics, and the 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 several sub-disciplines in their senior level elective offerings (digital, controls, communications, microelectronics design and fabrication).
4. Opportunities for students to develop sensitivity to the social and humanistic implications of technology and motivate them to make worth while contributions to the profession and society, while upholding the highest standards of professional ethics.
5. Courses in business and economics to promote awareness of management and the economic aspects of engineering.

6. Preparation for continuing study and professional development.

The curriculum offers students the opportunity to emphasize a number of specialized areas including digital systems, communications, controls, and microelectronic design and fabrication.

During the senior year, students must take the first step toward registration as a professional engineer by taking the Fundamentals of Engineering, (FE) examination as described in the GPA Policy below.

Minnesota State Mankato offers a 3/2 program with regional Liberal Arts colleges. Contact the department for more information.

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. Without this background it may take longer than four years to earn the degree. The first two years students take science and mathematics courses common to all branches of engineering (pre-engineering), as well as supporting work in English, humanities and social sciences. Second-year electrical engineering students complete physics, mathematics and 200-level engineering science courses. Some specialization for a particular engineering major occurs in the second year.


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

- a minimum of 32 earned semester credit hours.
- a minimum cumulative GPA of 2.00 (“C-”).

Contact the department for application procedures.

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

Before being accepted into the program and admitted to 300-level electrical engineering courses (typically in the fall semester), a student must complete a minimum of 61 semester credits including the following:

- General Physics (calculus-based) (12 credits)
- Calculus and Differential Equations (16 credits)
- Electrical Engineering Circuit Analysis I and II (including lab.) (7 credits)
- Chemistry (3 credits)
- English Composition (4 credits)
- Statics (3 credits)
- Machine Structures/Programming (3 credits)
- Microprocessor lab (1 credit)
- Introduction to EE/CE (6 credits)
- Speech (3 credits)
- Probability & Statistics or Engineering Analysis (3-credits)

A cumulative grade-point average of 2.5 for all science, math and engineering courses must have been maintained. Grades must be 2.0 (“C”) or better for courses to be accepted. Minnesota State Mankato students should complete the pre-engineering courses listed under the major.

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

1. completed a minimum of 20 semester credit hours of upper division EE course work;
2. have a cumulative GPA of 2.25 or higher in all upper division Minnesota State Mankato EE coursework;
3. have completed their senior design sequence at Minnesota State Mankato; and
4. have taken the FE exam and achieved the competency level set by the depart-


**ELECTRICAL ENGINEERING**

5. Grades must be 1.65 ("C-") or better for courses taken at Minnesota State Mankato to be accepted.

Petition to evaluate transfer credits must occur no later than the first semester the student is enrolled at Minnesota State Mankato.

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.

**P/N Grading Policy.** A student who majors in EE must elect the grade option for all courses even if offered by another department.

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**ELECTRICAL ENGINEERING BSEE**

**Required General Education**

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHEM 191</td>
<td>Chemistry for Engineers</td>
<td>3</td>
</tr>
<tr>
<td>ENG 101</td>
<td>Composition</td>
<td>4</td>
</tr>
<tr>
<td>MATH 121</td>
<td>Calculus I</td>
<td>4</td>
</tr>
<tr>
<td>PHYS 221</td>
<td>General Physics I</td>
<td>4</td>
</tr>
</tbody>
</table>

**Economics (Choose 3 credits from one of the following)**

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECON 201</td>
<td>Principles of Macroeconomics</td>
<td>3</td>
</tr>
<tr>
<td>ECON 202</td>
<td>Principles of Microeconomics</td>
<td>3</td>
</tr>
</tbody>
</table>

**Communication (Choose 3-4 credits from the following)**

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>CMST 102</td>
<td>Public Speaking</td>
<td>3</td>
</tr>
<tr>
<td>ENG 271W</td>
<td>Technical Communication</td>
<td>4</td>
</tr>
</tbody>
</table>

**Prerequisites to the Major**

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS 220</td>
<td>Machine Structures and Programming</td>
<td>3</td>
</tr>
<tr>
<td>EE 106</td>
<td>Introduction to Electrical/Computer Eng. I</td>
<td>3</td>
</tr>
<tr>
<td>EE 107</td>
<td>Introduction to Electrical/Computer Eng. II</td>
<td>3</td>
</tr>
<tr>
<td>EE 230</td>
<td>Circuit Analysis I</td>
<td>3</td>
</tr>
<tr>
<td>EE 231</td>
<td>Circuit Analysis II</td>
<td>3</td>
</tr>
<tr>
<td>EE 235</td>
<td>Microprocessor Engineering Laboratory I</td>
<td>1</td>
</tr>
<tr>
<td>EE 240</td>
<td>Evaluation of Circuits</td>
<td>1</td>
</tr>
<tr>
<td>MATH 122</td>
<td>Calculus II</td>
<td>4</td>
</tr>
<tr>
<td>MATH 223</td>
<td>Calculus III</td>
<td>4</td>
</tr>
<tr>
<td>MATH 321</td>
<td>Ordinary Differential Equations</td>
<td>4</td>
</tr>
<tr>
<td>ME 212</td>
<td>Statics</td>
<td>3</td>
</tr>
<tr>
<td>PHYS 222</td>
<td>General Physics II</td>
<td>3</td>
</tr>
<tr>
<td>PHYS 223</td>
<td>General Physics III</td>
<td>3</td>
</tr>
<tr>
<td>PHYS 232</td>
<td>General Physics II Lab</td>
<td>1</td>
</tr>
<tr>
<td>PHYS 233</td>
<td>General Physics III Lab</td>
<td>1</td>
</tr>
</tbody>
</table>

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**Major Common Core**

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
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</thead>
<tbody>
<tr>
<td>EE 281</td>
<td>Digital System Design with Testability</td>
<td>3</td>
</tr>
<tr>
<td>EE 282</td>
<td>Digital System Design with Testability Lab</td>
<td>1</td>
</tr>
<tr>
<td>EE 303</td>
<td>Introduction to Solid State Devices</td>
<td>3</td>
</tr>
<tr>
<td>EE 304</td>
<td>Lab: Introduction to Solid State Devices</td>
<td>1</td>
</tr>
<tr>
<td>EE 332</td>
<td>Electronics I</td>
<td>3</td>
</tr>
<tr>
<td>EE 333</td>
<td>Electronics II</td>
<td>3</td>
</tr>
<tr>
<td>EE 336</td>
<td>Principles of Engineering Design I</td>
<td>1</td>
</tr>
<tr>
<td>EE 337</td>
<td>Principles of Engineering Design II</td>
<td>1</td>
</tr>
<tr>
<td>EE 341</td>
<td>Signals and Systems</td>
<td>3</td>
</tr>
<tr>
<td>EE 342</td>
<td>Electronics Laboratory</td>
<td>1</td>
</tr>
<tr>
<td>EE 350</td>
<td>Engineering Electromagnetics</td>
<td>3</td>
</tr>
<tr>
<td>EE 353</td>
<td>Communications Systems Engineering</td>
<td>3</td>
</tr>
<tr>
<td>EE 358</td>
<td>Control Systems</td>
<td>3</td>
</tr>
<tr>
<td>EE 363</td>
<td>Communication Systems Laboratory</td>
<td>1</td>
</tr>
<tr>
<td>EE 368</td>
<td>Control Systems Laboratory</td>
<td>1</td>
</tr>
<tr>
<td>EE 450</td>
<td>Engineering Economics</td>
<td>3</td>
</tr>
<tr>
<td>EE 467</td>
<td>Principles of Engineering Design III</td>
<td>1</td>
</tr>
<tr>
<td>EE 477</td>
<td>Principles of Engineering Design IV</td>
<td>1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>EE 482</td>
<td>Electromechanics</td>
<td>3</td>
</tr>
</tbody>
</table>

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**Major Restricted Electives**

(Choose a minimum of 7 credits from the following courses (At least two (2) lecture courses must be in the same area)

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>EE 334</td>
<td>Microprocessor Engineering II</td>
<td>3</td>
</tr>
<tr>
<td>EE 344</td>
<td>Microprocessor II Laboratory</td>
<td>1</td>
</tr>
<tr>
<td>EE 453</td>
<td>Advanced Communications Systems Engineering</td>
<td>3</td>
</tr>
<tr>
<td>EE 471</td>
<td>Advanced Control Systems</td>
<td>3</td>
</tr>
<tr>
<td>EE 472</td>
<td>Digital Signal Processing</td>
<td>3</td>
</tr>
<tr>
<td>EE 475</td>
<td>Integrated Circuit Engineering</td>
<td>3</td>
</tr>
<tr>
<td>EE 476</td>
<td>Antennas, Propagation &amp; Microwave Engineering</td>
<td>3</td>
</tr>
<tr>
<td>EE 479</td>
<td>Superconductive Devices</td>
<td>3</td>
</tr>
<tr>
<td>EE 480</td>
<td>Integrated Circuit Fabrication Lab</td>
<td>1</td>
</tr>
<tr>
<td>EE 481</td>
<td>VLSI Design Laboratory</td>
<td>1</td>
</tr>
<tr>
<td>EE 484</td>
<td>VLSI Design</td>
<td>3</td>
</tr>
<tr>
<td>EE 487</td>
<td>RF Systems Engineering</td>
<td>3</td>
</tr>
</tbody>
</table>

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**Other Graduation Requirements**

Choose a minimum of thirteen (13) credits from Humanities (6-7 credits) and Social Sciences (6-7 credits) courses. For a complete listing of approved Humanities and Social Science courses, please consult the department website.

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH 354</td>
<td>Concepts of Probability &amp; Statistics</td>
<td>3</td>
</tr>
<tr>
<td>ME 291</td>
<td>Engineering Analysis</td>
<td>3</td>
</tr>
<tr>
<td>Thermal Systems</td>
<td>(Choose 2 credits)</td>
<td></td>
</tr>
<tr>
<td>EE 488</td>
<td>Thermal Systems Engineering</td>
<td>2</td>
</tr>
<tr>
<td>ME 299</td>
<td>Thermal Analysis</td>
<td>2</td>
</tr>
<tr>
<td>Business/Finance</td>
<td>(Choose 3 credits)</td>
<td></td>
</tr>
<tr>
<td>BLAW 200</td>
<td>Legal, Political, and Regulatory Environment of Business</td>
<td>3</td>
</tr>
<tr>
<td>FINA 362</td>
<td>Business Finance</td>
<td>3</td>
</tr>
<tr>
<td>MGMT 330</td>
<td>Principles of Management</td>
<td>3</td>
</tr>
<tr>
<td>MGMT 440</td>
<td>Human Resource Management</td>
<td>3</td>
</tr>
<tr>
<td>MRKT 310</td>
<td>Principles of Marketing</td>
<td>3</td>
</tr>
</tbody>
</table>

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**Related Graduation Requirements**

No minor or other major accepted toward degree.

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**COURSE DESCRIPTIONS**

**EE 106 (3) Introduction to Electrical/Computer Engineering I**

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.

Pre: MATH 112

Fall Spring

**EE 107 (3) Introduction to Electrical/Computer Engineering II**

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.

Pre: EE 106

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.
Pre: 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.
Pre: EE 230 and EE 240, MATH 321, PHYS 222
Spring

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.
Pre: EE 106, EE 107
Coreq: CS 200

EE 240 (1) Evaluation of Circuits
Pre: 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.
Pre: 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.
Pre: 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, PLAS, FPGAs and Memories. Analysis, synthesis and design of sequential machines; synchronous, pulse mode, asynchronous and incompletely specified logic.
Pre: EE 106, CS 220
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.
Pre: EE 281

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

EE 303 (3) Introduction to Solid State Devices
Introduction to crystal structure, energy band theory, conduction and optical phenomena 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.
Pre: 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.
Pre: EE 231
Fall

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.
Pre: 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.
Pre: 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.
Pre: 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.
Pre: 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 circuits.
Pre: EE 231 and EE 332 taken concurrently.
Fall

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EE 344 (1) Microprocessor II Laboratory
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.
Pre: Concurrent with EE 334
Fall

EE 350 (3) Engineering Electromagnetics
Pre: EE 231, MATH 223, MATH 321 and PHYS 222
Spring

EE 353 (3) Communications Systems Engineering
Pre: EE 341 & MATH 223
Spring

EE 358 (3) Control Systems
Pre: EE 341
Spring

EE 363 (1) Communication Systems Laboratory
Pre: 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.
Pre: EE 341 and concurrent with EE 358
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.
Pre: EE 932
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.
Pre: EE 235. At least 60 credits earned; in good standing; instructor permission; co-op contract; other prerequisites may also apply.
Fall, Spring, Summer

EE 439 (3) Electronics for Non-Electrical Engineering Majors
Topics covered include power supplies, operational amplifiers and feedback circuits, linear and nonlinear circuits and applications, analog switches, digital logic gates and devices, A/D and D/A converters, microprocessors, and basic control systems.
Pre: PHYS 221 and PHYS 222
Variable

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.
Pre: 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 demodulation/detection, bandpass modulation and demodulation of digital signals. Channel coding, modulation and coding trade-offs, spread spectrum techniques, probability and information theory.
Pre: 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.
Pre: EE 244

EE 467 (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.
Pre: EE 337 and senior standing
Fall

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.
Pre: 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.
Pre: 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.
Pre: EE 231 or via permission from instructor
Variable
**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.
Pre: 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.
Pre: EE 350
Variable

**EE 477 (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.
Pre: EE 467 and Senior Standing
Spring

**EE 479 (3) Superconductive Devices**
Pre: 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.
Pre: 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.
Pre: 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.
Pre: EE 230
Fall

**EE 484 (3) VLSI Design**
Pre: EE 333
Spring

**EE 487 (3) RF Systems Engineering**
Pre: EE 353 and EE 363
Variable

**EE 488 (2) Thermal Systems Engineering**
Pre: PHYS 222 and EE 333
Variable

**EE 491 (1-4) In-Service**

**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**