Electrical Engineering

Program Description

The Department of Electrical Engineering at Mines strives to produce leaders who serve the profession, the global community, and society. In addition to the program's ABET-accredited undergraduate curriculum, students attain technical expertise while completing course work and projects reflective of modern technology trends. Students consider the broader impacts of engineering solutions on society and human lives. Fundamental and applied engineering research in power and renewable energy, data sciences and control systems, and RF and wireless communications are offered which support the university's mission of “earth, energy, and environment.”

At the undergraduate level, the department focuses on a select number of areas in electrical engineering; specifically,

(1) power and energy systems (PES),
(2) integrated circuits, computer engineering and electronic systems (ICE),
(3) information and systems sciences (ISS), and
(4) antennas and wireless communications (AWC).

At the graduate level, the department provides educational and research opportunities in three selected topical areas:

(1) compressive sensing, data analysis, control and optimization;
(2) energy systems, electric power, power electronics, renewable energy, machines and drives,
(3) antennas, RF and microwaves, wireless communications, and computational electromagnetics.

Both undergraduate and graduate programs are characterized by strong ties with industrial partners (locally and nationally) that provide resources for students, laboratories, research projects, and ultimately career paths for our students.

BS in Electrical Engineering

PROGRAM EDUCATIONAL OBJECTIVES

The Electrical Engineering program contributes to the educational objectives described in the Mines' Graduate Profile. In addition, the Electrical Engineering Program at Mines has established the following program educational objectives:

Within three years of attaining the BSEE degree:

1. Graduates will be applying their professional Electrical Engineering skills and training in their chosen field or will be successfully pursuing a degree.
2. Graduates will be situated in growing careers, generating new knowledge and exercising professional leadership.
3. Graduates will be contributing to the needs of society through professional practice, research and service.

Program Educational Objectives

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- Graduates will be contributing to the needs of society through professional practice, research and service.

Student Learning Outcomes

1. An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.
2. An ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors.
3. An ability to communicate effectively with a range of audiences.
4. An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts.
5. An ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives.
6. An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions.
7. An ability to acquire and apply new knowledge as needed, using appropriate learning strategies.

Bachelor of Science in Electrical Engineering Degree Requirements:

Freshman				
Fall		**lec**	**lab**	**sem.hrs**
CHGN121	PRINCIPLES OF CHEMISTRY I			4.0
MATH111	CALCULUS FOR SCIENTISTS AND ENGINEERS I			4.0
HASS100	NATURE AND HUMAN VALUES			3.0
CSM101	FRESHMAN SUCCESS SEMINAR			1.0
Science Elective	CBEN110, GEGN101, CHGN122, or CHGN125			4.0
				16.0
Spring		**lec**	**lab**	**sem.hrs**
MATH112	CALCULUS FOR SCIENTISTS AND ENGINEERS II			4.0
EDNS151	CORNERSTONE - DESIGN I			3.0
PHGN100	PHYSICS I - MECHANICS			4.0
CSM202	INTRODUCTION TO STUDENT WELL-BEING AT MINES			1.0
CSCI128	COMPUTER SCIENCE FOR STEM			3.0
				15.0

Sophomore

Fall		lec	lab	sem.hrs
HASS200	GLOBAL STUDIES			3.0
MATH213	CALCULUS FOR SCIENTISTS AND ENGINEERS III			4.0
PHGN200	PHYSICS II-ELECTROMAGNETISM AND OPTICS (Distributed Science 3)			4.0
CSCI200	FOUNDATIONAL PROGRAMMING CONCEPTS & DESIGN			3.0
SUCCESS +WELLNESS	Choose one course from the following: CSM250 (1.0 credit), CSM275 (1 credit), CSM350 (3 credits), or PAGN2XX (1 credit)			1.0
				15.0

Spring		lec	lab	sem.hrs
MATH225	DIFFERENTIAL EQUATIONS			3.0
EBGN321	ENGINEERING ECONOMICS*For the 2023 Catalog EBGN321 replaced EBGN201 as a Core requirement. EBGN321 was added to the core, but has a prerequisite of 60 credit hours. Students whose programs that required EBGN201 the sophomore year may need to wait to take EBGN321 until their junior year. For complete details, please visit: https://www.mines.edu/registrar/core-curriculum/			3.0
EENG284	DIGITAL LOGIC			4.0
EENG282	ELECTRICAL CIRCUITS			4.0
FREE ELECTIVE				3.0
				17.0

Junior

Fall		lec	lab	sem.hrs
MATH332	LINEAR ALGEBRA			3.0
EENG307	INTRODUCTION TO FEEDBACK CONTROL SYSTEMS			3.0
EENG310	INFORMATION SYSTEMS SCIENCE I			3.0
EENG383	EMBEDDED SYSTEMS			4.0
EENG391	FE ON COMPUTATIONAL METHODS FOR ELECTRICAL ENGINEERING			1.0
EENG386	FUNDAMENTALS OF ENGINEERING ELECTROMAGNETICS			3.0
				17.0

Spring		lec	lab	sem.hrs
EENG385	ELECTRONIC DEVICES AND CIRCUITS			4.0
EENG311	INFORMATION SYSTEMS SCIENCE II			3.0
EENG389	FUNDAMENTALS OF ELECTRIC MACHINERY			4.0
EE ELECTIVE	Students must complete 15 credits of Electrical Engineering Electives from the approved list in the 2023-2024 catalog.			3.0
EENG350	SYSTEMS EXPLORATION AND ENGINEERING DESIGN LAB			3.0
				17.0

Senior

Fall		lec	lab	sem.hrs
CAS Elective	Culture and Society (CAS) Mid-Level Restricted Elective			3.0
CAS Elective	Culture and Society (CAS) Mid-Level Restricted Elective			3.0
EDNS491	CAPSTONE DESIGN I			3.0
EE Elective	Electrical Engineering Elective *			3.0
EE Elective	Electrical Engineering Elective *			3.0
EENG392	FE ON INFORMATION AND SYSTEMS SCIENCES, 393, or 394			1.0
				16.0

Spring		lec	lab	sem.hrs
CAS Elective	Culture and Society (CAS) 400-Level Restricted Elective			3.0
EDNS492	CAPSTONE DESIGN II			3.0
EE Elective	Electrical Engineering Elective *			3.0
EE ELECTIVE	Electrical Engineering Elective *			3.0
FREE ELECTIVE				3.0
				15.0

Total Semester Hrs: 128.0

* Electrical Engineering students are required to take five Electrical Engineering Electives from an approved list. See below for guidelines and the list of Electrical Engineering Electives:

Electrical Engineering Electives:

These Electrical Engineering Electives are open to all EE students. The interest pathways they fall under are: Information and Systems Science (ISS), Power and Energy Systems (PES), Integrated Circuits and Electronics (ICE), and Antennas and Wireless Communications (AWC).

Electrical Engineering students are required to complete 15 credits of Electrical Engineering Electives. At least 9 credits out of the 15 must be 400-level or higher EENG-prefix courses.

EENG390	ENERGY, ELECTRICITY, RENEWABLE ENERGY, AND ELECTRIC POWER GRID	3.0
EENG411	DIGITAL SIGNAL PROCESSING	3.0
EENG413	ANALOG AND DIGITAL COMMUNICATION SYSTEMS	4.0
EENG415	DATA SCIENCE FOR ELECTRICAL ENGINEERING	3.0
EENG417	MODERN CONTROL DESIGN	3.0

EENG421	SEMICONDUCTOR DEVICE PHYSICS AND DESIGN	3.0
EENG423	INTRODUCTION TO VLSI DESIGN	3.0
EENG425	INTRODUCTION TO ANTENNAS	3.0
EENG427	WIRELESS COMMUNICATIONS	3.0
EENG428	COMPUTATIONAL ELECTROMAGNETICS	3.0
EENG429	ACTIVE RF & MICROWAVE DEVICES	3.0
EENG430	PASSIVE RF & MICROWAVE DEVICES	3.0
EENG437	INTRODUCTION TO COMPUTER VISION	3.0
EENG470	INTRODUCTION TO HIGH POWER ELECTRONICS	3.0
EENG475	INTERCONNECTION OF RENEWABLE ENERGY, INTEGRATED POWER ELECTRONICS, POWER SYSTEMS, AND POWER QUALITY	3.0
EENG480	POWER SYSTEMS ANALYSIS	3.0
EENG481	ANALYSIS AND DESIGN OF ADVANCED ENERGY SYSTEMS	3.0
EENG486	ELECTROMAGNETIC FIELDS AND WAVES	3.0
EENG489	COMPUTATIONAL METHODS IN ENERGY SYSTEMS AND POWER ELECTRONICS	3.0
CSCI341	COMPUTER ORGANIZATION	3.0
CSCI410	ELEMENTS OF COMPUTING SYSTEMS	3.0
CSCI440	PARALLEL COMPUTING FOR SCIENTISTS AND ENGINEERS	3.0
CSCI442	OPERATING SYSTEMS	3.0
CEEN405	NUMERICAL METHODS FOR ENGINEERS	3.0
MEGN441	INTRODUCTION TO ROBOTICS	3.0
MATH335	INTRODUCTION TO MATHEMATICAL STATISTICS	3.0
MATH455	PARTIAL DIFFERENTIAL EQUATIONS	3.0
MEGN330	INTRODUCTION TO BIOMECHANICAL ENGINEERING	3.0
PHGN300	PHYSICS III-MODERN PHYSICS I	3.0
PHGN320	MODERN PHYSICS II: BASICS OF QUANTUM MECHANICS	4.0
PHGN435	INTERDISCIPLINARY MICROELECTRONICS PROCESSING LABORATORY	3.0
PHGN440	SOLID STATE PHYSICS	3.0
PHGN441	SOLID STATE PHYSICS APPLICATIONS AND PHENOMENA	3.0
PHGN462	ELECTROMAGNETIC WAVES AND OPTICAL PHYSICS	3.0

*Additional EENG or CSCI 400-level and graduate level classes taught by faculty in the EE department may be considered as Electrical Engineering Electives. Talk to your advisor for further guidance. 300-level or higher courses from other departments may be considered by the Department Head.

Major GPA

During the 2016-2017 Academic Year, the Undergraduate Council considered the policy concerning required major GPAs and which courses are included in each degree's GPA. While the GPA policy has not been officially updated, in order to provide transparency, council members agreed that publishing the courses included in each degree's GPA is beneficial to students.

The following list details the courses that are included in the GPA for this degree:

- EENG100 through EENG699 inclusive
- EDNS491 (EGGN491)
- EDNS492 (EGGN492)

Combined BS/MS in Electrical Engineering

The Department of Electrical Engineering offers a combined Bachelor of Science/Master of Science program in Electrical Engineering that enables students to work on a Bachelor of Science and a Master of Science simultaneously. This allows undergraduate students to take courses that will count for their graduate degree requirements, while still finishing their undergraduate degree requirements. This will be especially attractive to students who intend to go on to the graduate program, yet have availability in their schedules even while fulfilling the undergraduate requirements. Another advantage is an expedited graduate school application process, as described below.

Students must be admitted into the Combined BS/MS degree program prior to the close of registration of the term in which any course toward the MS degree will be applied. Typically this is the beginning of the student's Senior year, but students may apply as early as the first semester of their Junior year. Admissions must be granted no later than the end of registration in the last semester of the Senior year. In order to apply for the combined program, a pro forma graduate school application is submitted, and as long as the undergraduate portion of the program is successfully completed and the student has a GPA above 3.0, the student is admitted to the non#thesis Master of Science degree program in Electrical Engineering.

Students are required to take an additional 30 credits for the M.S. degree. Up to nine of the 30 credits beyond the undergraduate degree requirements can be 400-level courses. The remainder of the courses will be at the graduate level (500-level and above). There is no limit on the number of graduate level (500#level and above) courses a student may take beyond the undergraduate degree requirements, but a student must complete at least one semester as a registered graduate student after completion of the undergraduate degree before being awarded a graduate degree. Students must declare graduate courses through the Registrar's Office at time of registration. Grades count toward the graduate GPA and must meet the minimum grade requirements (C# or higher) to be counted toward graduation requirements. Courses may not be used to meet undergraduate financial aid requirements. Students will declare course work as regular graduate courses on Admission to Candidacy Form. Students should follow the MS Non#Thesis degree requirements based on their track in selecting appropriate graduate degree courses. Students may switch from the combined program which includes a non-thesis Master of Science degree to an M.S. degree with a thesis optional, however, if students change degree programs they must satisfy all degree requirements for the M.S. with thesis degree.

Combined Engineering Physics Baccalaureate and Electrical Engineering Masters Degrees

The Department of Electrical Engineering, in collaboration with the Department of Physics, offers a five-year program in which students have the opportunity to obtain specific engineering skill to complement their physics background. Physics students in this program fill in their technical and free electives over their standard four year Engineering Physics B.S. program with a reduced set of Electrical Engineering classes. At the end of the fourth year, the student is awarded an Engineering Physics B.S degree. Course schedules for this five-year program can be obtained in the Physics Departmental Offices.

The Mines guidelines for Minor/ASI can be found in the Undergraduate Information section of the Mines Catalog.

Electrical Engineering

ASI in Electrical Engineering

The following twelve credit sequence is required for an ASI in Electrical Engineering, The Mines guidelines for Minor/ASI can be found in the Undergraduate Information section of the Mines Catalog.

EENG281	INTRODUCTION TO ELECTRICAL CIRCUITS, ELECTRONICS AND POWER	3.0
or PHGN215	ANALOG ELECTRONICS	
EENG307	INTRODUCTION TO FEEDBACK CONTROL SYSTEMS	3.0
Complete remaining requirements by taking 6.0 credits of any EENG 300 or 400 level course.		

Minor in Electrical Engineering

A minimum of eighteen credits are required for a Minor in Electrical Engineering as follows. (See Minor/ASI section of the Bulletin for all rules for minors at Mines.)

Students must complete an eighteen credit sequence as described below for a minor in EE. All students seeking a minor in EE will need to take EENG282 (4 credits) and EENG307 (3 credits) after which they complete the remaining minor requirements.

1. Information Systems and Science (ISS), 18 or 20 credits

EENG282	ELECTRICAL CIRCUITS	4.0
EENG307	INTRODUCTION TO FEEDBACK CONTROL SYSTEMS	3.0
EENG284	DIGITAL LOGIC	4.0
EENG310	INFORMATION SYSTEMS SCIENCE I	3.0
EENG311	INFORMATION SYSTEMS SCIENCE II	3.0

2. Power and Energy Systems (PES), 18 credits

EENG282	ELECTRICAL CIRCUITS	4.0
EENG307	INTRODUCTION TO FEEDBACK CONTROL SYSTEMS	3.0
EENG385	ELECTRONIC DEVICES AND CIRCUITS	4.0
EENG386	FUNDAMENTALS OF ENGINEERING ELECTROMAGNETICS	3.0
EENG389	FUNDAMENTALS OF ELECTRIC MACHINERY	4.0

3. Digital Systems, 18 or 20 credits

EENG282	ELECTRICAL CIRCUITS	4.0
or EENG281 & MEGN300	INTRODUCTION TO ELECTRICAL CIRCUITS, ELECTRONICS AND POWER and INSTRUMENTATION & AUTOMATION	
EENG307	INTRODUCTION TO FEEDBACK CONTROL SYSTEMS	3.0
EENG284	DIGITAL LOGIC	4.0
EENG383	EMBEDDED SYSTEMS	4.0
EENG421	SEMICONDUCTOR DEVICE PHYSICS AND DESIGN	3.0
or EENG423	INTRODUCTION TO VLSI DESIGN	

4. General Electrical Engineering, 19 or 21 credits

EENG282	ELECTRICAL CIRCUITS	4.0
or EENG281 & MEGN300	INTRODUCTION TO ELECTRICAL CIRCUITS, ELECTRONICS AND POWER and INSTRUMENTATION & AUTOMATION	
EENG307	INTRODUCTION TO FEEDBACK CONTROL SYSTEMS	3.0
EENG284	DIGITAL LOGIC	4.0
EENG310	INFORMATION SYSTEMS SCIENCE I	3.0
EENG385	ELECTRONIC DEVICES AND CIRCUITS	4.0

Courses

EENG198. SPECIAL TOPICS. 1-6 Semester Hr.
(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

EENG199. INDEPENDENT STUDY. 1-6 Semester Hr.
(I, II) Individual research or special problem projects supervised by a faculty member, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: "Independent Study" form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

EENG281. INTRODUCTION TO ELECTRICAL CIRCUITS, ELECTRONICS AND POWER. 3.0 Semester Hrs.
This course provides an engineering science analysis of electrical circuits. DC and single-phase AC networks are presented. Transient analysis of RC, RL, and RLC circuits is studied as is the analysis of circuits in sinusoidal steady-state using phasor concepts. The following topics are included: DC and single-phase AC circuit analysis, current and charge relationships. Ohm's Law, resistors, inductors, capacitors, equivalent resistance and impedance, Kirchhoff's Laws, Thevenin and Norton equivalent circuits, superposition and source transformation, power and energy, maximum power transfer, first order transient response, algebra of complex numbers, phasor representation, time domain and frequency domain concepts, and ideal transformers. The course features PSPICE, a commercial circuit analysis software package. May not also receive credit for EENG282. Prerequisite: PHGN200.

EENG282. ELECTRICAL CIRCUITS. 4.0 Semester Hrs.
(I,II) This course provides an engineering science analysis of electrical circuits. DC and AC (single-phase and three-phase) networks are presented. Transient analysis of RC and RL circuits is studied as is the analysis of circuits in sinusoidal steady-state using phasor concepts. The following topics are included: DC and AC circuit analysis, current and charge relationships. Ohm's Law, resistors, inductors, capacitors, equivalent resistance and impedance, Kirchhoff's Laws, Thevenin and Norton equivalent circuits, superposition and source transformation, power and energy, maximum power transfer, first order transient response, algebra of complex numbers, phasor representation, time domain and frequency domain concepts, and steady-state analysis of single-phase and three-phase ac power circuits. May not also receive credit for EENG281. Prerequisites: PHGN200. 3 hours lecture; 3 hours lab; 4 semester hours.

EENG284. DIGITAL LOGIC. 4.0 Semester Hrs.
This course is an introduction to digital logic design. Students will start to learn how to design combinational logic circuit using Kmaps, manipulate these expressions using Boolean algebra and then produce basic building blocks like decoders and adders. Next students will focus on sequential logic circuits with basic memory elements, then design sequential building blocks like counters and registers and then to design finite state machines. Students will then learn how to combine basic building blocks with finite state machines to create complex functionality. Students will implement their design using a hardware description language and download these designs on FPGAs. Prerequisite: CSCI261 (C- or better) or CSCI200 (C- or better). Co-requisite: EENG282 or EENG281 or PHGN215.

EENG298. SPECIAL TOPICS IN ELECTRICAL ENGINEERING. 1-6 Semester Hr.
(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

EENG299. INDEPENDENT STUDY. 0.5-6 Semester Hr.
(I, II) Individual research or special problem projects supervised by a faculty member, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: "Independent Study" form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

EENG299. INDEPENDENT STUDY. 0.5-6 Semester Hr.
(I, II) Individual research or special problem projects supervised by a faculty member, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: "Independent Study" form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

EENG307. INTRODUCTION TO FEEDBACK CONTROL SYSTEMS. 3.0 Semester Hrs.
System modeling through an energy flow approach is presented, with examples from linear electrical, mechanical, fluid and/or thermal systems. Analysis of system response in both the time domain and frequency domain is discussed in detail. Feedback control design techniques, including PID, are analyzed using both analytical and computational methods. Prerequisite: EENG281 or EENG282 or PHGN215 (C- or better) and MATH225.

EENG310. INFORMATION SYSTEMS SCIENCE I. 3.0 Semester Hrs.
Equivalent with EENG388,
The interpretation, representation and analysis of time-varying phenomena as signals which convey information and noise; applications are drawn from filtering, audio and image processing, and communications. Topics include convolution, Fourier series and transforms, sampling and discrete-time processing of continuous-time signals, modulation, and z-transforms. 3 hours lecture; 1 hour recitation, 4 semester hours. Prerequisite: EENG281 or EENG282 or PHGN215 (C- or better) and MATH225. Co-requisite: EENG 391 (C- or better).

EENG311. INFORMATION SYSTEMS SCIENCE II. 3.0 Semester Hrs.
(I,II) This course covers signals and noise in electrical systems. Topics covered include information theory, signal to noise ratio, random variables, probability density functions, statistics, noise, matched filters, coding and entropy, power spectral density, and bit error rate. Applications are taken from radar, communications systems, and signal processing. Prerequisite: EENG310. 3 hours lecture; 3 semester hours.

EENG340. COOPERATIVE EDUCATION. 3.0 Semester Hrs.
(I,II,S) Supervised, full-time engineering- related employment for a continuous six-month period in which specific educational objectives are achieved. Students must meet with the Engineering Division Faculty Co-op Advisor prior to enrolling to clarify the educational objectives for their individual Co-op program. 3 semester hours credit will be granted once toward degree requirements. Credit earned in EGGN340, Cooperative Education, may be used as free elective credit hours or a civil specialty elective if, in the judgment of the Co-op Advisor, the required term paper adequately documents the fact that the work experience entailed high-quality application of engineering principles and practice. Applying the credits as free electives or civil electives requires the student to submit a ?Declaration of Intent to Request Approval to Apply Co-op Credit toward Graduation Requirements? form obtained from the Career Center to the Engineering Division Faculty Co-op Advisor.

EENG350. SYSTEMS EXPLORATION AND ENGINEERING DESIGN LAB. 3.0 Semester Hrs.
This laboratory is a semester-long design and build activity centered around a challenge problem that varies from year to year. Solving this problem requires the design and prototyping of a complex system and utilizes concepts from multiple electrical engineering courses. Students work in intra-disciplinary teams to build modular sub-systems and integrate them to a complete system.

EENG383. EMBEDDED SYSTEMS. 4.0 Semester Hrs.
(I, II) The design and implementation of systems consisting of analog and digital components with a microcontroller to perform a dedicated task. Student will implement systems using a variety of microcontroller subsystems including timers, PWM, ADC, serial communication subsystems and interrupts. Students will learn embedded systems programming techniques like, fixed-point math, direct digital synthesis, lookup tables, and row scanning. Student will program the microcontroller using a high-level programming language like C or C++. Prerequisite: EENG281 or EENG282 or PHGN215 (C-or better) and EENG284 or PHGN317 (C-or better).

EENG385. ELECTRONIC DEVICES AND CIRCUITS. 4.0 Semester Hrs.
Students will study the large signal and small signal behavior of active components including opamps, diodes, bipolar junction transistors, and field effect transistors. Students will explore the frequency response analysis of standard circuit configurations. Students will engage laboratory exercises to compare how well their theoretical analysis compare to the actual circuit. 3 hours lecture; 3 hours lab; 4 semester hours. Prerequisite: EENG307.

EEENG386. FUNDAMENTALS OF ENGINEERING ELECTROMAGNETICS. 3.0 Semester Hrs.

This course introduces electromagnetic theorems leading to engineering applications related to antennas, wireless communications, and microwave devices. Maxwell?s equations will be introduced and analyzed for static and time varying applications. They will also be used to describe electric and magnetic fields behavior in space and time and how they represent energy transmission and radiation. A review of vector calculus and coordinates systems will be conducted first as they are essential in understanding and manipulations of several electromagnetic theorems. 3 hours lecture; 3 semester hours. 3 hours lecture; 3 semester hours. Prerequisite: EENG281 (C- or better) or EENG282 (C- or better), and MATH225.

EENG389. FUNDAMENTALS OF ELECTRIC MACHINERY. 4.0 Semester Hrs.

(I, II) This course provides an engineering analysis of electrical machines. The following topics are included: review of three-phase AC circuit analysis, magnetic circuit concepts and materials, transformer analysis and operation, modelling, steady-state analysis of rotating machines, synchronous and poly-phase induction motors, and DC machines and laboratory study of external characteristics of machines and transformers. Prerequisite: EENG281 (C- or better) or EENG282 (C- or better). 3 hours lecture, 3 hours lab; 4 semester hours.

EENG390. ENERGY, ELECTRICITY, RENEWABLE ENERGY, AND ELECTRIC POWER GRID. 3.0 Semester Hrs.

(I) (WI) Fundamentals and primary sources of energy; Energy conversion; Comprehensive energy picture in USA and the world; Generation of electric power today; Understanding of the electric power grid and how it works; Renewable energy resources and distributed generation; Wind and PV power generation; Future trend in electricity delivery; Energy sustainability. 3 hours lecture; 3 semester hours. Prerequisite: EENG281 or EENG282 or PHGN215.

EENG391. FE ON COMPUTATIONAL METHODS FOR ELECTRICAL ENGINEERING. 1.0 Semester Hr.

Students will learn computational methods for common tasks in electrical engineering such as creating and plotting signals and data, analyzing and implementing digital filters, numerically computing integrals, solving differential equations, and simulating dynamical systems. Prerequisite: EENG281 or EENG282, PHGN215 (C- or better), MATH225. Co-requisite: EENG310 (C- or better).

EENG392. FE ON INFORMATION AND SYSTEMS SCIENCES. 1.0 Semester Hr.

(II) The course will present hardware and software solutions for the purpose of creating customized instrumentation and control systems. Concepts presented include 1) User Interface Design: controls, indicators, dialogs, graphs, charts, tab controls, user interface best practices 2) Software Development: basic software architecture, loops, arrays, binary logic, mathematics, data management 3) Instrumentation basics: connecting sensors to hardware, acquiring data, analyzing instrumentation accuracy, examining resolution and noise characteristics of a signal 4) Control basics: create pulse-width modulated (PWM) signals for controlling motors, servos, amplifiers, and heaters. Create a PID control algorithm to control a dynamic system. 1 hour lecture; 2 hours lab; 1 semester hour. Prerequisite: EENG281 or EENG282 and CSCI261 or CSCI200. Co-requisite: EENG307.

EENG393. FE ON INTEGRATED CIRCUITS AND ELECTRONICS PRACTICUM. 1.0 Semester Hr.

(I) Students will learn how to design, fabricate, and solder a printed circuit board (PCB) from concept to implementation. In addition to teaching best design practices, the course will address the variety of real-world constraints that impact the manufacturing of electrical circuits on PCBs. Prerequisite: EENG383 or EENG385. 1 hour lecture; 2 hours lab; 1 semester hour.

EENG394. FE ON ANTENNAS AND WIRELESS COMMUNICATIONS. 1.0 Semester Hr.

(I) This course provides the basic theories of electromagnetics, antennas, and wireless communications. Hands on experience will be developed during the projects assigned in the class to design antennas and passive microwave devices. 0.5 hours lecture; 1.5 hours lab; 1 semester hour.

EENG395. UNDERGRADUATE RESEARCH. 1-3 Semester Hr.

(I, II) Individual research project for freshman, sophomores or juniors under direction of a member of the departmental faculty. Written report required for credit. Seniors should take EENG495 instead of EENG395. Repeatable for credit. Variable credit; 1 to 3 semester hours.

EENG398. SPECIAL TOPICS IN ELECTRICAL ENGINEERING. 6.0 Semester Hrs.

(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

EENG399. INDEPENDENT STUDY. 1-6 Semester Hr.

(I, II) Individual research or special problem projects supervised by a faculty member, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: "Independent Study" form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

EENG411. DIGITAL SIGNAL PROCESSING. 3.0 Semester Hrs.

(II) This course introduces the mathematical and engineering aspects of digital signal processing (DSP). An emphasis is placed on the various possible representations for discrete-time signals and systems (in the time, z-, and frequency domains) and how those representations can facilitate the identification of signal properties, the design of digital filters, and the sampling of continuous-time signals. Advanced topics include sigma-delta conversion techniques, multi-rate signal processing, and spectral analysis. The course will be useful to all students who are concerned with information bearing signals and signal processing in a wide variety of application settings, including sensing, instrumentation, control, communications, signal interpretation and diagnostics, and imaging. Prerequisite: EENG310. 3 hours lecture; 3 semester hours.

EENG413. ANALOG AND DIGITAL COMMUNICATION SYSTEMS. 4.0 Semester Hrs.

(II) Signal classification; Fourier transform; filtering; sampling; signal representation; modulation; demodulation; applications to broadcast, data transmission, and instrumentation. Prerequisite: EENG310. 3 hours lecture; 3 hours lab; 4 semester hours.

EENG415. DATA SCIENCE FOR ELECTRICAL ENGINEERING. 3.0 Semester Hrs.

This course presents a comprehensive exposition of the theory, methods, and algorithms for data analytics as related to power and energy systems. It will focus on (1) techniques for performing statistical inference based on data, (2) methods for predicting future values of data, (3) methods for classifying data instances into relevant classes and clusters, (4) methods for building, training and testing artificial neural networks, and (5) techniques for evaluating the effectiveness and quality of a data analytics model. Prerequisite: EENG311.

EENG417. MODERN CONTROL DESIGN. 3.0 Semester Hrs.

(I) Control system design with an emphasis on observer-based methods, from initial open-loop experiments to final implementation. The course begins with an overview of feedback control design technique from the frequency domain perspective, including sensitivity and fundamental limitations. State space realization theory is introduced, and system identification methods for parameter estimation are introduced. Computerbased methods for control system design are presented. Prerequisite: EENG307. 3 lecture hours, 3 semester hours.

EENG421. SEMICONDUCTOR DEVICE PHYSICS AND DESIGN. 3.0 Semester Hrs.

(I) This course will explore the field of semiconductors and the technological breakthroughs which they have enabled. We will begin by investigating the physics of semiconductor materials, including a brief foray into quantum mechanics. Then, we will focus on understanding pn junctions in great detail, as this device will lead us to many others (bipolar transistors, LEDs, solar cells). We will explore these topics through a range of sources (textbooks, scientific literature, patents) and discuss the effects they have had on Western society. As time allows, we will conclude with topics of interest to the students (possibilities include quantum devices, MOSFETs, lasers, and integrated circuit fabrication techniques). Prerequisite: PHGN200. 3 hours lecture; 3 semester hours.

EENG423. INTRODUCTION TO VLSI DESIGN. 3.0 Semester Hrs.

(II) This is an introductory course that will cover basic theories and techniques of digital VLSI (Very Large Scale Integrated Circuits) design and CMOS technology. The objective of this course is to understand the theory and design of digital systems at the transistor level. The course will cover MOS transistor theory, CMOS processing technology, techniques to design fast digital circuits, techniques to design power efficient circuits, standard CMOS fabrications processes, CMOS design rules, and static and dynamic logic structures. Prerequisites: EENG281 (C- or better) or EENG282 (C- or better), and EENG284 (C- or better). 3 hours lecture; 3 semester hours.

EENG425. INTRODUCTION TO ANTENNAS. 3.0 Semester Hrs.

(II) This course provides an introduction to antennas and antenna arrays. Theoretical analysis and use of computer programs for antenna analysis and design will be presented. Experimental tests and demonstrations will also be conducted to complement the theoretical analysis. Students are expected to use MATLAB to model antennas and their performance. Prerequisites: EENG386.

EENG427. WIRELESS COMMUNICATIONS. 3.0 Semester Hrs.

This course provides the tools needed to analyze and design a wireless system. Topics include link budgets, satellite communications, cellular communications, handsets, base stations, modulation techniques, RF propagation, coding, and diversity. Students are expected to complete an extensive final project. Prerequisite: EENG311 or MATH201 and EENG310.

EENG428. COMPUTATIONAL ELECTROMAGNETICS. 3.0 Semester Hrs.

This course provides the basic formulations and numerical solutions for static and full wave electromagnetic problems. Static problems are based on Laplace and Poisson equations while full wave electromagnetic problems are based on differential and integral forms of Maxwell?s equations. Different numerical methods will be introduced such as: finite difference, finite difference frequency domain, finite difference time domain, and method of moments. The numerical development and implementation of these methods using MATLAB will be conducted to solve practical problems. 3 hours lecture; 3 semester hours. 3 hours lecture; 3 semester hours. Prerequisite: EENG386.

EENG429. ACTIVE RF & MICROWAVE DEVICES. 3.0 Semester Hrs.

(II) This course introduces the basics of active radio-frequency (RF) and microwave circuits and devices which are the building blocks of modern communication and radar systems. The topics that will be studied are RF and microwave circuit components, resonant circuits, matching networks, noise in active circuits, switches, RF and microwave transistors and amplifiers. Additionally, mixers, oscillators, transceiver architectures, RF and monolithic microwave integrated circuits (RFICs and MMICs) will be introduced. Moreover, students will learn how to model active devices using professional CAD software, how to fabricate printed active microwave devices, how a vector network analyzer (VNA) operates, and how to measure active RF and microwave devices using VNAs. Prerequisites: EENG385. 3 hours lecture; 3 semester hours.

EENG430. PASSIVE RF & MICROWAVE DEVICES. 3.0 Semester Hrs.

(I) This course introduces the basics of passive radio-frequency (RF) and microwave circuits and devices which are the building blocks of modern communication and radar systems. The topics that will be studied are microwave transmission lines and waveguides, microwave network theory, microwave resonators, power dividers, directional couplers, hybrids, RF/microwave filters, and phase shifters. Students will also learn how to design and analyze passive microwave devices using professional CAD software. Moreover, students will learn how to fabricate printed passive microwave devices and test them using a vector network analyzer. Prerequisites: EENG386. 3 hours lecture; 3 semester hours.

EENG437. INTRODUCTION TO COMPUTER VISION. 3.0 Semester Hrs.

(I) Computer vision is the process of using computers to acquire images, transform images, and extract symbolic descriptions from images. This course provides an introduction to this field, covering topics in image formation, feature extraction, location estimation, and object recognition. Design ability and hands-on projects will be emphasized, using popular software tools. The course will be of interest both to those who want to learn more about the subject and to those who just want to use computer imaging techniques. 3 hours lecture; 3 semester hours. Prerequisite: MATH201 or EENG311, MATH332, CSCI261 or CSCI200, Senior level standing.

EENG470. INTRODUCTION TO HIGH POWER ELECTRONICS. 3.0 Semester Hrs.

(I) Power electronics are used in a broad range of applications from control of power flow on major transmission lines to control of motor speeds in industrial facilities and electric vehicles, to computer power supplies. This course introduces the basic principles of analysis and design of circuits utilizing power electronics, including AC/DC, AC/AC, DC/DC, and DC/AC conversions in their many configurations. 3 hours lecture; 3 semester hours. Prerequisite: EENG282, EENG389.

EENG475. INTERCONNECTION OF RENEWABLE ENERGY, INTEGRATED POWER ELECTRONICS, POWER SYSTEMS, AND POWER QUALITY. 3.0 Semester Hrs.
This course focuses on different aspects of interconnection of distributed renewable generation resources at the power distribution and transmission levels. Students will have a clear understanding of the source and electrical characteristics of different renewable energy sources and the challenges associated with the integration of renewable generation resources with the current power grid. Hands-on simulation-based case studies will help the students examine the covered topics on realistic power system models and understand how renewable energy interconnection issues affect power and voltage quality. Students will also be introduced to the US electricity markets and the role of renewable energy and energy storage in providing deliverable energy flexibility. The course consists of a mathematical and analytical understanding of relevant electrical energy conversion systems analysis and modeling issues. Prerequisite: EENG282, EENG389, EENG470.

EENG480. POWER SYSTEMS ANALYSIS. 3.0 Semester Hrs.
(I) 3-phase power systems, per-unit calculations, modeling and equivalent circuits of major components, voltage drop, fault calculations, symmetrical components and unsymmetrical faults, system grounding, power-flow, selection of major equipment, design of electric power distribution systems. Prerequisite: EENG389. 3 hours lecture; 3 semester hours.

EENG481. ANALYSIS AND DESIGN OF ADVANCED ENERGY SYSTEMS. 3.0 Semester Hrs.
The course investigates the design, operation and analysis of complex interconnected electric power grids, the basis of our electric power infrastructure. Evaluating the system operation, planning for the future expansion under deregulation and restructuring, ensuring system reliability, maintaining security, and developing systems that are safe to operate has become increasingly more difficult. Because of the complexity of the problems encountered, analysis and design procedures rely on the use of sophisticated power system simulation computer programs. The course features some commonly used commercial software packages. Prerequisite: EENG480.

EENG486. ELECTROMAGNETIC FIELDS AND WAVES. 3.0 Semester Hrs.
(I) This course provides an introduction to electromagnetic fields and waves and their applications in antennas, radar, high-frequency electronics, and microwave devices. The time-varying form of electromagnetic fields and the use of sinusoidal time sources to create time-harmonic electromagnetic fields will be covered first, followed by coverage of plane electromagnetic waves formulation and reflection and transmission from different surfaces. Finally, the application of guided electromagnetic waves will be covered through the study of transmission lines, waveguides, and their applications in microwave systems. Prerequisite: EENG386. 3 hours lecture; 3 semester hours.

EENG489. COMPUTATIONAL METHODS IN ENERGY SYSTEMS AND POWER ELECTRONICS. 3.0 Semester Hrs.
The course presents a unified approach for understanding and applying computational methods, computer-aided analysis and design of electric power systems. Applications will range from power electronics to power systems, power quality, and renewable energy. Focus will be on how these seemingly diverse applications all fit within the smart-grid paradigm. This course builds on background knowledge of electric circuits, control of dc/dc converters and inverters, energy conversion and power electronics by preparing students in applying the computational methods for multi-domain simulation of energy systems and power electronics engineering problems. Prerequisite: EENG282, EENG389, EENG470.

EENG495. UNDERGRADUATE RESEARCH. 1-3 Semester Hr.
(I, II) Individual research project under direction of a member of the departmental faculty. Written report required for credit. Prerequisites: senior-level standing based on credit hours. Variable credit; 1 to 3 semester hours. Repeatable for credit.

EENG498. SPECIAL TOPICS IN ELECTRICAL ENGINEERING. 1-6 Semester Hr.
(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

EENG499. INDEPENDENT STUDY. 1-6 Semester Hr.
(I, II) Individual research or special problem projects supervised by a faculty member, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: "Independent Study" form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

EENG499. INDEPENDENT STUDY. 1-6 Semester Hr.
(I, II) Individual research or special problem projects supervised by a faculty member, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: "Independent Study" form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

Professor and Department Head

Peter Aaen

Professors

Atef Elsherbeni

Kathryn Johnson

Tyrone Vincent

Michael Wakin

Associate professors

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Gabriel Santamaria-Botello

Teaching Professors

Abd Arkadan

Chris Coulston

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Prachi Sharma

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