Electrical Engineering

Degrees Offered

- Professional Online Masters in Electrical Engineering *This degree can be earned by completing the last three certificates listed below plus one additional course.
- Master of Science (Electrical Engineering)
- Doctor of Philosophy (Electrical Engineering)
- Graduate Certificate in Data Science for Signals and Systems
- Graduate Certificate in Information and Systems Sciences
- Graduate Certificate in Microwave Engineering
- Graduate Certificate in Power and Energy Systems

Program Overview

The Electrical Engineering Department offer the degrees Master of Science and Doctor of Philosophy in Electrical Engineering. These degree programs demand academic rigor and depth yet also address real-world problems.

The Department has three areas of research activity that stem from the core fields of Electrical Engineering: 1) Antennas and Wireless Communications, 2) Information and Systems Science, and 3) Power and Energy Systems. Individual research projects may encompass more than one research area.

Research Areas:

Antennas and Wireless Communications is a research area that builds on the fundamental physics and mathematics of electromagnetic waves and propagation. The research in this area includes design, analysis, optimization, and measurement of antennas, antenna arrays, microwave, millimeter-wave, and terahertz devices. Applications address current academic, industry, and society needs, such as wireless communication systems, radar and remote sensing, and electromagnetic imaging.

Information and Systems Sciences is an interdisciplinary research area that encompasses the fields of control systems, data science, optimization, signal and image processing, compressive sensing, robotics, and mechatronics. Applications can be found in renewable energy and power systems, materials processing, sensor and control networks, bio-engineering, computer vision and pattern recognition, autonomous systems, imaging, intelligent structures, and geosystems.

Power and Energy Systems is focused on both fundamental and applied research in the interrelated fields of conventional electric power systems and electric machinery, renewable energy and distributed generation, energy economics and policy issues, power quality, power electronics and drives. The overall scope of research encompasses a broad spectrum of electrical energy applications including investor-owned utilities, rural electric associations, manufacturing facilities, regulatory agencies, and consulting engineering firms.

Program Details

The Electrical Engineering Department offers the degrees Master of Science and Doctor of Philosophy in Electrical Engineering. The master's program is designed to prepare candidates for careers in industry or government or for further study at the PhD level; both thesis and non-thesis options are available. The PhD degree program is sufficiently flexible to prepare candidates for careers in industry, government, or academia. See the information that follows for full details on these four degrees.

Mines Combined Undergraduate/Graduate Degree Program

Students enrolled in Mines' combined undergraduate/graduate program may double count up to 6 credits of graduate coursework to fulfill requirements of both their undergraduate and graduate degree programs. These courses must have been passed with B- or better, not be substitutes for required coursework, and meet all other university, department, and program requirements for graduate credit.

Students are advised to consult with their undergraduate and graduate advisors for appropriate courses to double count upon admission to the combined program.

Prerequisites

Requirements for Admission to EE: The minimum requirements for admission to the MS and PhD degrees in Electrical Engineering are:

- A baccalaureate degree in engineering, computer science, a physical science, or math with a grade-point average of 3.0 or better on a 4.0 scale.
- Graduate Record Examination (Quantitative section) score of 151 or higher (or 650 on the old scale). Applicants who have graduated with an engineering degree from Mines within the past five years are not required to submit GRE scores.
- TOEFL score of 79 or higher (or 550 for the paper-based test or 213 for the computer-based test) for applicants whose native language is not English. In lieu of a TOEFL score, an IELTS score of 6.5 or higher will be accepted.
- For the PhD program, prior research experience is desired but not required.

Admitted Students: The EE department graduate committee may require that an admitted student take undergraduate remedial coursework to overcome technical deficiencies. The committee will decide whether to recommend regular or provisional admission.

Transfer Courses: Graduate-level courses taken at other universities for which a grade equivalent to a B or better was received will be considered for transfer credit with approval of the advisor and/or thesis committee, and EE department head, as appropriate. Transfer credits must not have been used as credit toward a bachelor's degree. For the MS degree, no more than 9 credits may transfer. For the PhD degree, up to 24 credits may be transferred. In lieu of transfer credit for individual courses, students who enter the PhD program with a thesis-based master's degree from another institution may transfer up to 36 hours in recognition of the coursework and research completed for that degree.

Advisor and Thesis Committee: Students must have an advisor from the EE faculty to direct and monitor their academic plan, research, and independent studies. Advisors must be full-time permanent members of the faculty. In this context, full-time permanent members of the faculty are those that hold the rank of professor, associate professor, assistant professor, research professor, associate research professor or assistant research professor. Upon approval by the graduate dean, adjunct faculty, teaching faculty, visiting professors, emeritus professors and off-campus representatives may be designated additional co-advisors. A list of EE faculty by rank is available in the faculty tab in the catalog.

Master of Science (thesis option) students must have at least three members on their thesis committee; the advisor and one other member must be permanent faculty in the EE department. Students who choose to have a minor program must select a representative from the minor area of study to serve on the thesis committee.
PhD thesis committees must have at least four members; the advisor and two additional members must be permanent faculty in the EE department, and one member must be outside the departmental faculty and serving as chair of the committee. Students who choose to have a minor program must select a representative from the minor area of study to serve on the thesis committee.

Degree Audit and Admission to Candidacy: All degree students must submit required forms by the deadlines posted by the Office of Graduate Studies

Master students must complete the Degree Audit form by the posted deadline.
PhD students need to submit the Degree Audit form by the posted deadline and need to submit the Admission to Candidacy form by the first day of the semester in which they want to be considered eligible for reduced registration.

Time Limit: As stipulated by the Mines Graduate School, a candidate for a master's degree must complete all requirements for the degree within five years of the date of admission into the degree program. A candidate for a doctoral degree must complete all requirements for the degree within nine years of the date of admission into the degree program.

Program Requirements

Master of Science – Electrical Engineering

The MS degree in Electrical Engineering (thesis or non-thesis Option) requires 30 credits. All MS students are also required to enroll in the zero-credit course EENG 500 Graduate Seminar each semester . Requirements for the thesis MS are 24 hours of coursework and 6 credits of thesis research. The non-thesis option requires 30 credits of coursework. A maximum of 6 credits of independent study can be used to fulfill degree requirements. There are three tracks in Electrical Engineering: 1) Antennas and Wireless Communications (AWC), 2) Power and Energy Systems (PES), and 3) Information and Systems Sciences (ISS). Students are encouraged to decide between tracks before pursuing an advanced degree. Students are also encouraged to speak to their advisor and/or a member of the EE faculty before registering for classes and to select a permanent advisor as soon as possible. The following set of courses is required of all students.

MS Thesis - Electrical Engineering

EENG707	GRADUATE THESIS / DISSERTATION RESEARCH CREDIT	6.0
EENG500	ELECTRICAL ENGINEERING SEMINAR (All tracks) Enrollment required every fall and spring semester	0.0
EE CORE: EE Core Courses (AWC track)		9.0
EE CORE: EE Core Courses (PES track)		0.0
EE CORE: EE Core Courses (ISS track)		12.0
TECHNICAL ELECTIVES Technical Electives must be approved by Thesis Committee		
AWC Technical Electives		15.0
PES Technical Electives		24.0
ISS Technical Electives		12.0

MS Thesis Defense: At the conclusion of the MS (thesis option), the student will be required to make a formal presentation and defense of her/his thesis research.

MS Non-Thesis - Electrical Engineering

EENG500	ELECTRICAL ENGINEERING SEMINAR (All tracks) Enrollment required every fall and spring semester	0.0
EE CORE: EE Core Courses (AWC track)		9.0
EE CORE: EE Core Courses (PES track)		0.0
EE CORE: EE Core Courses (ISS track)		12.0
TECHNICAL ELECTIVES Technical Electives must be approved by Advisor		
AWC Technical Electives		15.0
PES Technical Electives		24.0
ISS Technical Electives		12.0
EE Electives (all tracks) Must be taught by an EE graduate faculty or approved by Advisor		6.0

Doctor of Philosophy - Electrical Engineering

The PhD degree in Electrical Engineering requires 72 credits of coursework and research credits. A minimum of 36 credits of coursework and a minimum of 24 credits of research is required. The remaining 12 credits required can be earned through research or coursework and students should consult with their advisor and/or thesis committee. The students are also required to enroll in the zero-credit course EENG 500 Graduate Seminar each semester. There are three tracks in Electrical Engineering: 1) Antennas and Wireless Communications (AWC), 2) Power and Energy Systems (PES), and 3) Information and Systems Sciences (ISS). Students are encouraged to decide between tracks before pursuing an advanced degree. Students are also encouraged to speak to their advisor and/or a member of the EE faculty before registering for classes and to select a permanent advisor as soon as possible. The following set of courses is required of all students.

EENG707	GRADUATE THESIS / DISSERTATION RESEARCH CREDIT	24.0
EENG500	ELECTRICAL ENGINEERING SEMINAR (All tracks) Enrollment required every fall and spring semester	0.0
EE CORE: EE Core Courses (AWC track)		9.0
EE CORE: EE Core Courses (PES track)		0.0
EE CORE: EE Core Courses (ISS track)		12.0
EE Technical Electives Technical Electives must be approved by Thesis Committee		
AWC Technical Electives		27.0
PES Technical Electives		36.0
ISS Technical Electives		24.0

PhD Qualifying Examination

Students wishing to enroll in the Electrical Engineering PhD program will be required to pass a qualifying exam. Normally, full-time PhD candidates will take the qualifying exam in their first year, but it must be taken within four semesters of entering the program. Part-time candidates will normally be expected to take the qualifying exam within no more than six semesters of entering the program.

The purpose of the qualifying exam is to assess some of the attributes expected of a successful PhD student, including:

- To determine the student's ability to review, synthesize and apply fundamental concepts.
- To determine the creative and technical potential of the student to solve open-ended and challenging problems.
- To determine the student's technical communication skills.

The qualifying exam includes both written and oral sections. The written section is based on material from the EE department's undergraduate Electrical Engineering degree. The oral part of the exam covers one or more papers from the literature chosen by the student and the student's advisor. The student's advisor and two additional Electrical Engineering faculty members (typically from the student's thesis committee representing their track) administer the oral exam.

PhD qualifying exams will be held each spring semester. In the event of a student failing the qualifying exam, she/he will be given one further opportunity to pass the exam in the following spring semester. If a second failure occurs, the student has unsatisfactory academic performance that results in an immediate, mandatory dismissal of the graduate student from the PhD program.

PhD Thesis Proposal

After passing the qualifying exam, the PhD student is allowed up to 18 months to prepare a written thesis proposal and present it formally to the student's graduate committee and other interested faculty.

Admission to Candidacy: In addition to the Graduate School requirements, full-time students must complete the following requirements within two calendar years of enrolling in the PhD program.

- Have a thesis committee appointment form on file in the Graduate Office:
- Have passed the PhD qualifying exam demonstrating adequate preparation for, and satisfactory ability to conduct doctoral research.

PhD Thesis Defense

At the conclusion of the student's PhD program, the student will be required to make a formal presentation and defense of her/his thesis research. The EE department enforces a defense policy for PhD students with regards to their publications and presentations. According to this policy, the required and recommended publications and presentations for EE PhD students before graduation are listed below:

- Journal Publications
    - Required: Minimum of one first-author paper accepted or published in a peer-reviewed journal before the dissertation defense.
    - Recommended: Three or more first-author papers accepted or published in peer-reviewed journals. More than three first-author journal publications are recommended for students interested in academic positions.
- Presentations
    - Required: Minimum of one research presentation (poster or oral presentation) before the dissertation defense. Possible venues include an external technical conference, the campus-wide graduate student research conference, the departmental colloquium, or a sponsor meeting.
    - Recommended: Two or more research presentations at external technical conferences where the student is the first author on the presented work. Numerous conference presentations are strongly encouraged to establish a research reputation for students interested in academic positions.
- Exceptions: Students wanting to defend before meeting these requirements must submit a one-page petition with reasonable explanation to the EE graduate committee. Certain conferences, particularly some related to Computer Science, publish longer papers and have high standards for acceptance and thus may be considered as journal-quality. Finally, while some journals may have lengthy review timelines and thus some students may wish to defend their dissertation while a journal paper is still under review, students should be aware that peer review comments and final decisions provide valuable input to a dissertation committee in assessing a student's research. Reviews from intermediate conference publications can help in assessing a recent journal submission.
- MS thesis students: It is recommended that students pursuing a thesis-based MS degree have submitted at least one paper to a peer-reviewed journal or conference and given at least one research presentation (poster or oral presentation) before the dissertation defense.

Electrical Engineering Courses

Required Core: Antennas and Wireless Communications Track

All students must take three of the following five core courses.

EENG525	ANTENNAS	3.0
EENG526	ADVANCED ELECTROMAGNETICS	3.0
EENG527	WIRELESS COMMUNICATIONS	3.0
EENG528	COMPUTATIONAL ELECTROMAGNETICS	3.0
EENG530	PASSIVE RF & MICROWAVE DEVICES	3.0

Required Core: Power and Energy Systems Track

There is no core course requirement for the PES track.

Required Core: Information and Systems Sciences Track

All students must take:

EENG515	MATHEMATICAL METHODS FOR SIGNALS AND SYSTEMS	3.0

and choose at least three of the following:

EENG509	SPARSE SIGNAL PROCESSING	3.0
EENG511	CONVEX OPTIMIZATION AND ITS ENGINEERING APPLICATIONS	3.0
EENG517	THEORY AND DESIGN OF ADVANCED CONTROL SYSTEMS	3.0
EENG519	ESTIMATION THEORY AND KALMAN FILTERING	3.0
EENG527	WIRELESS COMMUNICATIONS	3.0

EENG589	DESIGN AND CONTROL OF WIND ENERGY SYSTEMS	3.0
MEGN544	ROBOT MECHANICS: KINEMATICS, DYNAMICS, AND CONTROL	3.0

Professional Online Masters in Electrical Engineering

The professional master's degree is designed to train and target recent graduates or mid-career professionals with a B.S. in electrical engineering or a related field in physics or applied sciences. The program is composed of 3 stackable certificates plus a required graduate-level mathematics course (MEGN502). To complete the professional master's degree the student must complete 30 credits as outlined below.

Students may also register for the professional masters at the outset and take a mixture of courses (from the tracks) in any order. Should the student elect to register for the full masters, then certificates will not be awarded on completion of the full degree. For these students, we refer to the certificates as 'tracks' as no certificates will be awarded.

Certificate 1 / Track 1: Information and System Sciences – students must complete 9 hours of coursework as follows:

EENG510	ADVANCED DIGITAL SIGNAL PROCESSING	3.0
EENG515	MATHEMATICAL METHODS FOR SIGNALS AND SYSTEMS	3.0
EENG519	ESTIMATION THEORY AND KALMAN FILTERING	3.0

Certificate 2 / Track 2 : Microwave Engineering – students must complete 9 hours of coursework as follows:

EENG529	ACTIVE RF & MICROWAVE DEVICES	3.0
EENG530	PASSIVE RF & MICROWAVE DEVICES	3.0
EENG532	LOW TEMPERATURE MICROWAVE MEASUREMENTS FOR QUANTUM ENGINEERING	3.0

Certificate 3 / Track 3: Power & Energy Systems – students must complete 9 hours of coursework as follows:

EENG570	ADVANCED HIGH POWER ELECTRONICS	3.0
EENG577	ADVANCED ELECTRICAL MACHINE DYNAMICS FOR SMART-GRID SYSTEMS	3.0
EENG585	AI FOR POWER AND RENEWABLE ENERGY SYSTEMS	3.0

While all courses are to be delivered online, students that are interested in attending an on-campus class, may substitute one of the above courses per each certificates (or track) with one of the with appropriate track electives as listed in our Graduate Catalog.

Graduate certificate in information and system sciences

The post-baccalaureate certificate program in Information and System Sciences is targeted to train recent graduates or mid-career professionals with a basic knowledge of modeling and extracting information from signals, systems, or data sets.

To earn the post-baccalaureate certificate program in Information and System Sciences, students must complete 9 hours of coursework as follows:

Required Courses:

EENG510	ADVANCED DIGITAL SIGNAL PROCESSING	3.0
EENG515	MATHEMATICAL METHODS FOR SIGNALS AND SYSTEMS	3.0
EENG519	ESTIMATION THEORY AND KALMAN FILTERING	3.0

While all courses are to be delivered online, students that are interested in attending an on-campus class may substitute one of the above courses with one of the Information and Systems Sciences track electives as listed in our Graduate Catalog.

Graduate certificate in microwave engineering

The online certificate program in Microwave Engineering is targeted to train recent graduates or mid-career professionals with a B.S. in electrical engineering or a related field in physics or applied sciences with a basic knowledge of electromagnetic theory, specifically for handling the challenges and demands of modern microwave systems.

To complete the online certificate program in Microwave Engineering, students must complete 9 hours of coursework as follows:

Required Courses:

EENG529	ACTIVE RF & MICROWAVE DEVICES	3.0
EENG530	PASSIVE RF & MICROWAVE DEVICES	3.0
EENG532	LOW TEMPERATURE MICROWAVE MEASUREMENTS FOR QUANTUM ENGINEERING	3.0

While all courses are to be delivered online, students that are interested in attending an on-campus class may substitute one of the above courses with one of the Antennas & Wireless electives as listed in our Graduate Catalog.

graduate certificate in power and energy systems

The online certificate program in Power and Energy Systems is targeted to train recent graduates or mid-career professionals with a B.S. in electrical engineering or a related field in physics or applied sciences with a basic knowledge of power systems and machines.

To complete the online certificate program in Power and Energy Systems, students must complete 9 hours of coursework as follows:

Required Courses:

EENG570	ADVANCED HIGH POWER ELECTRONICS	3.0
EENG577	ADVANCED ELECTRICAL MACHINE DYNAMICS FOR SMART-GRID SYSTEMS	3.0
EENG585	AI FOR POWER AND RENEWABLE ENERGY SYSTEMS	

While all courses are to be delivered online, students that are interested in attending an on-campus class may substitute one of the above courses with one of the Power and Energy Systems electives as listed in our Graduate Catalog.

Graduate Certificate in Data Science for Signals and Systems

The graduate certificate program in Data Science for Signals and Systems is targeted to train recent graduates or mid-career professionals with a BS in electrical engineering or a related field in mathematical and algorithmic aspects of data science relevant for electrical engineers, specifically for handling the signals and data that are processed and created by modern physical and virtual electrical systems.

To earn the graduate certificate in Data Science for Signals and Systems, students must complete 12 credits as follows:

Required Courses:

EENG514	DATA SCIENCE FOR ELECTRICAL ENGINEERING	3.0
EENG515	MATHEMATICAL METHODS FOR SIGNALS AND SYSTEMS	3.0

Choose 2 out of 5:

EENG509	SPARSE SIGNAL PROCESSING	3.0
EENG511	CONVEX OPTIMIZATION AND ITS ENGINEERING APPLICATIONS	3.0
EENG519	ESTIMATION THEORY AND KALMAN FILTERING	3.0
EENG521	NUMERICAL OPTIMIZATION	3.0
EENG586	COMMUNICATION NETWORKS FOR POWER SYSTEMS	3.0

Courses

EENG500. ELECTRICAL ENGINEERING SEMINAR. 0.0 Semester Hrs.
This zero-credit graduate course builds on the EE department seminars in the colloquium series, which consist of presentations delivered by external or internal invited speakers on topics broadly related to electrical engineering. The seminar is mandatory for all graduate students (MS and Ph.D.). The students would need to enroll in the course every semester. Any student who cannot take the course for valid reasons should notify their adviser, who will then make a request to the EE graduate committee for a waiver. These requests could be for the duration of one semester or longer. The course will be graded as PRG/PRU based on student attendance at the department seminars in the colloquium series - the student has to attend at least two thirds of all the seminars each semester in order to get a PRG grade.
Course Learning Outcomes

- Graduates will demonstrate the ability to conduct directed research.
- Graduates will demonstrate oral and written communication skills.

EENG507. INTRODUCTION TO COMPUTER VISION. 3.0 Semester Hrs.
Equivalent with CSCI507,CSCI512,EENG512,
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.
Course Learning Outcomes

- 1. Be able to analyze and predict the behavior of image formation, transformation, and recognition algorithms.
- 2. Be able to design, develop, and evaluate algorithms for specific applications.
- 3. Be able to use software tools to implement computer vision algorithms.
- 4. Communicate (in oral and written form) methods and results to a technical audience.

EENG508. ADVANCED TOPICS IN PERCEPTION AND COMPUTER VISION. 3.0 Semester Hrs.
Equivalent with CSCI508,
This course covers advanced topics in perception and computer vision, emphasizing research advances in the field. The course focuses on structure and motion estimation, general object detection and recognition, and tracking. Projects will be emphasized, using popular software tools. 3 hours lecture; 3 semester hours. Prerequisite: EENG507 or CSCI507.
Course Learning Outcomes

- 1. Be able to review the literature on computer vision and create a critical review
- 2. Be able to design, develop, and evaluate algorithms for specific applications
- 3. Be able to use software tools to implement computer vision algorithms
- 4. Communicate (in oral and written form) methods and results to a technical audience

EENG509. SPARSE SIGNAL PROCESSING. 3.0 Semester Hrs.
This course presents a mathematical tour of sparse signal representations and their applications in modern signal processing. The classical Fourier transform and traditional digital signal processing techniques are extended to enable various types of computational harmonic analysis. Topics covered include time-frequency and wavelet analysis, filter banks, nonlinear approximation of functions, compression, inverse problems, compressive sensing, and connections with machine learning. Offered Spring semester of even years. Prerequisites: EENG411 and EENG515 or instructor consent.
Course Learning Outcomes

- 1. Students will develop the link between the Fourier, time-frequency, and wavelet transforms.
- 2. Students will be introduced to the concepts of linear and nonlinear approximation of functions.
- 3. Students will be able to use sparse signal representations for solving signal restoration and inverse problems.

EENG510. ADVANCED DIGITAL SIGNAL PROCESSING. 3.0 Semester Hrs.
Equivalent with CSCI510,EGGN510,
This course covers 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. Deterministic and random signal and noise models are discussed, as are methods for noise removal and power spectrum estimation. Additional topics include multi-rate signal processing and spectral analysis using the discrete Fourier transform. 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, EENG 311, EENG 391; or consent of instructor.

EENG511. CONVEX OPTIMIZATION AND ITS ENGINEERING APPLICATIONS. 3.0 Semester Hrs.

The course focuses on recognizing and solving convex optimization problems that arise in applications in various engineering fields. Covered topics include basic convex analysis, conic programming, duality theory, unconstrained optimization, and constrained optimization. The application part covers problems in signal processing, power and energy, machine learning, control and mechanical engineering, and other fields, with an emphasis on modeling and solving these problems using the CVX package. Offered Spring semester of even years. Prerequisite: EENG515 or instructor consent.

Course Learning Outcomes

- 1. Recognize convex optimization problems that arise in applications
- 2. Understand the basic theory of convex optimization
- 3. Understand how convex optimizations are solved and solve them using various free packages
- 4. Use convex optimization in their research work or applications

EENG514. 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. 3 hours lecture, 3 semester hours. Prerequisite: EENG311. Co-requisite: None.

Course Learning Outcomes

- No changes to current class outcomes.

EENG515. MATHEMATICAL METHODS FOR SIGNALS AND SYSTEMS. 3.0 Semester Hrs.

(I) An introduction to mathematical methods for modern signal processing using vector space methods. Topics include signal representation in Hilbert and Banach spaces; linear operators and the geometry of linear equations; LU, Cholesky, QR, eigen- and singular value decompositions. Applications to signal processing and linear systems are highlighted, such as least-squares estimation, spectral analysis, principal component analysis, and signal classification. Offered every Fall semester.

EENG517. THEORY AND DESIGN OF ADVANCED CONTROL SYSTEMS. 3.0 Semester Hrs.

This course will introduce and study the theory and design of multivariable and nonlinear control systems. Students will learn to design multivariable controllers that are both optimal and robust, using tools such as state space and transfer matrix models, nonlinear analysis, optimal estimator and controller design, and multi-loop controller synthesis. Offered Spring semester of even years. Prerequisite: EENG417.

Course Learning Outcomes

- 1. define control-oriented problem statements for real-world problems,
- 2. model, analyze, and design controllers and estimators for single-input, single-output (SISO) and multi-input, multi-output (MIMO) systems in time and frequency domains,
- 3. design optimal and robust controllers and estimators for these systems,
- 4. model, analyze, and design controllers for nonlinear systems,
- 5. explain the connection between state-space and transfer function representations of systems and the effects on controller design and analysis
- 6. model, analyze, and design feedback control systems using MATLAB and Simulink in both the time and frequency domains, and
- 7. understand and apply basic educational and learning theories and tools that will enhance your lifelong learning.

EENG519. ESTIMATION THEORY AND KALMAN FILTERING. 3.0 Semester Hrs.

Estimation theory considers the extraction of useful information from raw sensor measurements in the presence of signal uncertainty. Common applications include navigation, localization and mapping, but applications can be found in all fields where measurements are used. Mathematic descriptions of random signals and the response of linear systems are presented. The discrete-time Kalman Filter is introduced, and conditions for optimality are described. Implementation issues, performance prediction, and filter divergence are discussed. Adaptive estimation and nonlinear estimation are also covered. Contemporary applications will be utilized throughout the course. Offered Spring semester of odd years. 1.5 hours lecture; 1.5 hours other; 3 semester hours.

Course Learning Outcomes

- Use Bayes' rule to calculate a statistical inference. Given a description of a stochastic process, calculate the joint and conditional probabilities for this process.
- Using the appropriate algorithm, calculate the probability distribution function for the state of a dynamic system with stochastic inputs.
- " Build a model of a dynamic system that includes a probabilistic description of uncertain inputs.
- Design and implement an algorithm to estimate the internal states of a linear system with input signals that are Gaussian stochastic processes.
- Design and implement an algorithm to estimate the internal states of general systems with general stochastic inputs.

EENG521. NUMERICAL OPTIMIZATION. 3.0 Semester Hrs.

Optimization is an indispensable tool for many fields of science and engineering. This course focuses on the algorithmic aspects of optimization. Covered topics include first-order (gradient descent and its variants) and second-order methods (Newton and quasi-Newton methods) for unconstrained optimization, theory and algorithms for constrained optimization, stochastic optimization and random search, derivative-free optimization, dynamic programming and simulation-based optimization, and distributed and parallel optimization. The emphasis will be on how the algorithms work, why they work, how to implement them numerically, and when to use which algorithm, as well as applications in different science and engineering fields. Offered Spring semester of odd years.

Course Learning Outcomes

- Recognize different types of optimizations, their targeting application areas, and the most suitable algorithms to solve them.
- Understand the mechanisms for different numerical algorithms and the scenarios that they work best.
- Be able to implement optimization algorithms numerically and tune the hyper-parameters
- Understand optimality conditions for constrained and unconstrained optimizations and use them to design algorithms.

- Use existing optimization packages to quickly prototype and solve optimization formulations of your problems.
- Know how to model, solve, and analyze optimization problems arising in various application fields.

EENG525. ANTENNAS. 3.0 Semester Hrs.
This course provides an in depth introduction to the analysis and synthesis of antennas and antenna arrays. Students are expected to use MATLAB to model antennas and their performance. An extensive final project that involves experimental or computer demonstrations is required. EENG525 has more depth and required work than EENG425. EENG525 students will have one additional problem for each homework assignment, one additional problem on exam, more difficult paper to review and present, and higher expectations on antenna and direction finding projects. Offered every Spring semester. Prerequisite: EGGN386 or GPGN302 or PHGN384.
Course Learning Outcomes

- At the completion of this course, students will know: 1. the properties of many different types of antennas. 2. how to select an appropriate antenna for a wireless system. 3. how to design an antenna that meets system specifications. 4. how to design and synthesize antenna arrays.

EENG526. ADVANCED ELECTROMAGNETICS. 3.0 Semester Hrs.
In this course the fundamental theorems of electromagnetics are developed rigorously. Wave solutions are developed in Cartesian, cylindrical, and spherical coordinate systems for bounded and unbounded regions.
Course Learning Outcomes

- 1. Learn the basics of electromagnetic theories and how to work with Maxwell’s equations to solve for wave propagation in bounded and unbounded regions.
- 2. Learn how to build and perfect the development of analytical solutions to canonical problems in different coordinate systems.
- 3.Learn how to develop computational tools and to validate the accuracy of generated numerical results

EENG527. WIRELESS COMMUNICATIONS. 3.0 Semester Hrs.
Equivalent with EENG513,
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. EENG527 has more depth and required work than EENG427. EENG527 students will have one additional problem for each homework assignment, one additional problem on exam, more difficult paper to review and present, and higher expectations on final project. Offered every Spring semester. Prerequisite: EENG386, EENG311, and EENG388.
Course Learning Outcomes

- Be able to calculate the link budget of a wireless communications system
- . Understand wireless propagation mechanisms and be able to estimate effects on signals
- 3. Be able to apply statistical channel models to wireless channels
- Understand antenna properties associated with wireless communications
- Describe, analyze, and understand engineering tradeoffs associated with modulation, coding, multiple access, and spread spectrum techniques

EENG528. COMPUTATIONAL ELECTROMAGNETICS. 3.0 Semester Hrs.
This course provides the basic formulation and numerical solution for static electric problems based on Laplace, Poisson and wave equations and for full wave electromagnetic problems based on Maxwell's equations. Variation principles methods, including the finite-element method and method of moments will be introduced. Field to circuit conversion will be discussed via the transmission line method. Numerical approximations based on the finite difference and finite difference frequency domain techniques will also be developed for solving practical problems. Offered every Fall semester.
Course Learning Outcomes

- Learn how to work with differential and integral equations representing field quantities into a computational model.
- Learn how to build and perfect the development of a computational model to solve electromagnetic problems
- Learn how to develop visualization tools and to validate the accuracy of generated numerical results

EENG529. ACTIVE RF & MICROWAVE DEVICES. 3.0 Semester Hrs.
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. Offered every Spring semester. Prerequisite: EENG385 and EENG430 or EENG530.
Course Learning Outcomes

- 1. Learn how to analyze and design a variety of active RF and microwave devices such as power amplifiers
- 2. Understand the basic operation mechanism of transmitters and receivers in communication systems
- 3. Gain a basic understanding on how vector network analyzers operate and how to measure active microwave devices
- 4. Learn how to model active microwave circuits and devices using a professional CAD tool.

EENG530. PASSIVE RF & MICROWAVE DEVICES. 3.0 Semester Hrs.
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. Offered every Fall semester.
Course Learning Outcomes

- 1. Learn how to analyze and design a variety of passive RF and microwave devices such as power dividers and filters
- 2. Understand the basic operation mechanism of multiport microwave networks and systems
- 3. Learn how to use vector network analyzers for measurement of passive microwave devices
- 4. Learn how to model passive microwave circuits and devices using a professional CAD tool.

EENG531. ACTIVE NONLINEAR RF & MICROWAVE DEVICES. 3.0 Semester Hrs.

This course introduces the basics of active nonlinear radio-frequency (RF) and microwave circuits and devices which are the building blocks of modern communication and radar systems. The topics that will be introduced are nonlinear phenomenon and related analysis and design techniques such as harmonic balance and Volterra series. Students will then apply this knowledge to design, analyze, fabricate, and test several nonlinear devices such as rectifiers, power amplifiers, oscillators, and mixers. Students will learn how to design and analyze these devices using professional CAD software and how to measure active nonlinear RF and microwave devices using VNAs. Offered on demand.

Course Learning Outcomes

- Learn the basics of nonlinear analysis and design techniques for active rf and microwave devices.
- Learn the basic operating principles of a variety of active nonlinear devices such as rectifiers, power amplifiers, and mixers.
- Gain the knowledge to design and analyze nonlinear devices using a commercial software.
- Understand the fundamental differences in linear and nonlinear active device measurements.

EENG532. LOW TEMPERATURE MICROWAVE MEASUREMENTS FOR QUANTUM ENGINEERING. 3.0 Semester Hrs.

The goal of the course is to provide hands on training in high-frequency, low-temperature measurements which are requisite for quantum information applications. This course introduces the fundamentals of high-frequency measurements, the latest techniques for accuracy-enhanced automated microwave measurements, low-temperature measurement techniques, low noise measurements, and common devices used in quantum information. The course will have three modules. The first module, basics of electronic measurements, will include chip layout, power measurements, ground loop testing, impedance measurements, noise fundamentals, cable and device fabrication and care. The second module, high frequency measurements, will include measurements of basic scattering parameters, accuracy enhancement and calibration, transmission line, amplifier, and oscillator characterization including noise measurements. The third module, low-temperature measurements, will cover critical parameters for superconductors and Josephson junctions, measurements of superconducting resonators, characterization of low-temperature electronic elements including amplifiers. At the end of this course the students will know how to use network analyzers, spectrum analyzers, cryostats, the software Eagle for chip design, amplifiers, and filters. Offered every Spring semester.

Course Learning Outcomes

- 1. Describe key RF, wireless and microwave measurement parameters
- 2. Understand how to use a range of RF, wireless and microwave test equipment
- 3. Reduce the risk of expensive test equipment damage, repair costs and downtime
- 4. Understand how to correctly perform common RF and microwave measurements
- 5. Understand the basics of low-temperature measurements including critical parameters for superconductors and Josephson junctions, as well as characterization of low-temperature electronic elements
- 6. Better utilize test and measurement equipment features and functionality
- 7. Develop improved problem solving capability due to better understanding

EENG536. PHASED & ADAPTIVE ARRAYS. 3.0 Semester Hrs.

This course introduces the basic fundamentals of phased arrays and adaptive antenna arrays with a focus on array processing. The topics that will be introduced are antenna array fundamentals and radiation analysis techniques, elements for antenna arrays, linear, planar, and non-planar arrays, focused arrays, radiation pattern synthesis, phased array and adaptive array system architectures, phase-delay and time-delay systems, analog and digital beamforming, adaptive nulling algorithms and interference cancellation, and angle of arrival estimation algorithms. This foundational knowledge will then be used by the students to conduct a comprehensive course project on a special topic in this area.

Course Learning Outcomes

- At the completion of this course, students will learn the basics of array processing and gain a fundamental understanding of the following topics: 1. Antenna Array Fundamentals and Analysis Techniques 2. Linear, Planar, and Non-Planar Arrays 3. Radiation Pattern Synthesis 4. Phased Array Beamforming 5. Digital Beamforming and Interference Cancelation 6. Digital Beamforming and Angle of Arrival Estimation

EENG540. INTRODUCTION TO RADAR SYSTEMS. 3.0 Semester Hrs.

This course provides an introduction to radar system engineering, it covers the fundamental concepts needed to understand the design and operation of modern radar systems for a variety of applications. Topics covered include the radar equation, radar cross section, radar clutter, detection and receiver design, transmitters and antenna systems. Applications include pulsed, continuous-wave, and frequency-modulated radars, Doppler radar, and synthetic aperture radar. Demonstrations will be conducted to complement the theoretical analysis.

Course Learning Outcomes

- Learn the basic concepts, operation, and techniques necessary to analyze and access the performance of modern radar systems
- Learn the components of a radar system and their relationship to overall system performance and to be able to specify the subsystem performance requirements in a radar system design.
- Learn how to develop computer programs to analyze and visualize radar signals, phased array patterns, and RSC of targets.

EENG570. ADVANCED HIGH POWER ELECTRONICS. 3.0 Semester Hrs.

Basic principles of analysis and design of circuits utilizing high power electronics. AC/DC, DC/AC, AC/AC, and DC/DC conversion techniques. Laboratory project comprising simulation and construction of a power electronics circuit. Offered Fall semester of even years. Prerequisites: EENG470 or instructor consent.

Course Learning Outcomes

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EENG571. MODERN ADJUSTABLE SPEED ELECTRIC DRIVES. 3.0 Semester Hrs.
An introduction to electric drive systems for advanced applications. The course introduces the treatment of vector control of induction and synchronous motor drives using the concepts of general flux orientation and the feedforward (indirect) and feedback (direct) voltage and current vector control. AC models in space vector complex algebra are also developed. Other types of drives are also covered, such as reluctance, stepper-motor and switched-reluctance drives. Digital computer simulations are used to evaluate such implementations. Offered on demand in spring semesters. Prerequisites: EENG470 or instructor consent.
Course Learning Outcomes

EENG572. RENEWABLE ENERGY AND DISTRIBUTED GENERATION. 3.0 Semester Hrs.
A comprehensive electrical engineering approach on the integration of alternative sources of energy. One of the main objectives of this course is to focus on the inter-disciplinary aspects of integration of the alternative sources of energy which will include most common and also promising types of alternative primary energy: hydropower, wind power, photovoltaic, fuel cells and energy storage with the integration to the electric grid.

EENG573. ELECTRIC POWER QUALITY. 3.0 Semester Hrs.
Electric power quality (PQ) deals with problems exhibited by voltage, current and frequency that typically impact end-users (customers) of an electric power system. This course is designed to familiarize the concepts of voltage sags, harmonics, momentary disruptions, and waveform distortions arising from various sources in the system. A theoretical and mathematical basis for various indices, standards, models, analyses techniques, and good design procedures will be presented. Additionally, sources of power quality problems and some remedies for improvement will be discussed. The course bridges topics between power systems and power electronics. Offered Spring semester of even years. Prerequisites:EENG480 and EENG470 or instructor consent.
Course Learning Outcomes

EENG577. ADVANCED ELECTRICAL MACHINE DYNAMICS FOR SMART-GRID SYSTEMS. 3.0 Semester Hrs.
This course provides engineering science analysis and focuses on the application of the abc frame of reference to develop state space and equivalent network models for electric machines and drive systems. The course focuses primarily on the modeling and dynamic performance prediction of electric machines and associated power electronic in smart grids and renewable energy systems/subsystems. The developed models will be used in computer simulations for the characterization and performance prediction of synchronous and induction machines, permanent magnet synchronous machines synchronous reluctance and switched reluctance machines, as well as other advanced machine systems, such as axil flux generators and Linear PM machines. Offered Spring semester of odd years. Prerequisites: EENG389 and EENG470.
Course Learning Outcomes

- LO-1 Explain the principles of operation of three-phase electric machines (synchronous; induction; permanent magnet synchronous; synchronous reluctance; switched reluctance, or other advanced machine systems, such as axil flux generators and linear PM), and describe machine modes of operation (motoring, generation).
- LO-2 Illustrate and describe equivalent circuit model of a machine and relate its parameters and terminal inputs/outputs to those of an actual device.
- LO-3 Implement a smart grid subsystem with one or multiple electric machine in a computer tool (MATLAB/SIMULINK or as specified) using the equivalent circuit models developed in this course.
- LO-4 Predict and analyze electric machine external operational characteristics (current, voltage, power, energy, torque, speed, losses, efficiency, etc.) as part of a renewable energy system or a smart grid subsystem using computer models developed by students.

EENG580. POWER DISTRIBUTION SYSTEMS ENGINEERING. 3.0 Semester Hrs.
This course deals with the theory and applications of problems and solutions as related to electric power distribution systems engineering from both ends: end-users like large industrial plants and electric utility companies. The primary focus of this course in on the medium voltage (4.16 kV ? 69 kV) power systems. Some references will be made to the LV power system. The course includes per-unit methods of calculations; voltage drop and voltage regulation; power factor improvement and shunt compensation; short circuit calculations; theory and fundamentals of symmetrical components; unsymmetrical faults; overhead distribution lines and power cables; basics and fundamentals of distribution protection. Offered in fall semester of odd years. Prerequisites: EENG480 or instructor consent.
Course Learning Outcomes

EENG581. POWER SYSTEM OPERATION AND MANAGEMENT. 3.0 Semester Hrs.
This course presents a comprehensive exposition of the theory, methods, and algorithms for Energy Management Systems (EMS) in the power grid. It will focus on (1) modeling of power systems and generation units, (2) methods for dispatching generating resources, (3) methods for accurately estimating the state of the system, (4) methods for assessing the security of the power system, and (5) an overview of the market operations in the grid. Offered Fall semester of even years. Prerequisite: EENG480 or instructor consent.

EENG582. HIGH VOLTAGE AC AND DC POWER TRANSMISSION. 3.0 Semester Hrs.
This course deals with the theory, modeling and applications of HV and EHV power transmission systems engineering. The primary focus is on overhead AC transmission line and voltage ranges between 115 kV to 500 kV. HVDC and underground transmission will also be discussed. The details include the calculations of line parameters (RLC); steady-state performance evaluation (voltage drop and regulation, losses and efficiency) of short, medium and long lines; reactive power compensation; FACTS devices; insulation coordination; corona; insulators; sag-tension calculations; EMTP, traveling wave and transients; fundamentals of transmission line design; HV and EHV power cables: solid dielectric, oil-filled and gas-filled; Fundamentals of DC transmission systems including converter and filter.
Course Learning Outcomes

EENG583. ADVANCED ELECTRICAL MACHINE DYNAMICS. 3.0 Semester Hrs.
This course deals primarily with the two rotating AC machines currently utilized in the electric power industry, namely induction and synchronous machines. The course is divided in two halves: the first half is dedicated to induction and synchronous machines are taught in the second half. The details include the development of the theory of operation, equivalent circuit models for both steady-state and transient operations, all aspects

of performance evaluation, IEEE methods of testing, and guidelines for industry applications including design and procurement.

Course Learning Outcomes

EENG584. POWER SYSTEM RISK MANAGEMENT. 3.0 Semester Hrs.

This course presents a comprehensive exposition of the theory, methods, and algorithms for risk management in the power grid. The course will focus on: (1) power system stability analysis (steady state, dynamic, and transient), (2) analysis of internal and external threats to power systems, e.g. component failures, faults, natural hazards, cyber intrusions, (3) introduction to power system security assessment, (4) fundamentals of modeling risk, vulnerability assessment and loss calculations, (5) mitigating techniques before, during and after the course of major events and disturbances. Offered Spring semester of odd years. Prerequisites: EENG480 and EENG481.

Course Learning Outcomes

- Power system stability analysis under different timeframes of interest
- Threats to power systems
- Power system risk assessment
- Mitigating risks imposed on the power system
- Comprehensive risk management

EENG586. COMMUNICATION NETWORKS FOR POWER SYSTEMS. 3.0 Semester Hrs.

Advanced topics on communication networks for power systems including the fundamentals of communication engineering and signal modulation/transfer, physical layer for data transfer (e.g., wireline, wireless, fiber optics), different communication topologies for power networks (e.g., client-server, peer-to-peer), fundamentals of SCADA system, data modeling and communication services for power system applications, common protocols for utility and substation automation, and cyber-security in power networks. Offered Fall semester of odd years. Prerequisite: EENG480 or instructor consent.

EENG587. POWER SYSTEMS PROTECTION AND RELAYING. 3.0 Semester Hrs.

Theory and practice of power system protection and relaying; Study of power system faults and symmetrical components; Fundamental principles and tools for system modeling and analysis pertaining to relaying, and industry practices in the protection of lines, transformers, generators, motors, and industrial power systems; Introduction to microprocessor based relaying, control, and SCADA.

Course Learning Outcomes

EENG588. ENERGY POLICY, RESTRUCTURING AND DEREGULATION OF ELECTRICITY MARKET. 3.0 Semester Hrs.

The big picture of electric power, electricity and energy industry; Restructuring and Deregulation of electricity market; Energy Policy Acts and its impact on electricity market and pricing; Energy economics and pricing strategy; Public policy issues, reliability and security; Regulation.

EENG589. DESIGN AND CONTROL OF WIND ENERGY SYSTEMS. 3.0 Semester Hrs.

Wind energy provides a clean, renewable source for electricity generation. Wind turbines provide electricity at or near the cost of traditional fossil-fuel fired power plants at suitable locations, and the wind industry is growing rapidly as a result. Engineering R&D can still help to reduce the cost of energy from wind, improve the reliability of wind turbines and wind farms, and help to improve acceptance of wind energy in the public and political arenas. This course will provide an overview of the design and control of wind energy systems. Offered Spring semester of odd years. Prerequisite: EENG307.

EENG598. SPECIAL TOPICS IN ELECTRICAL ENGINEERING. 6.0 Semester Hrs.

(I, II, S) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once, but no more than twice for the same course content. Prerequisite: none. Variable credit: 0 to 6 credit hours. Repeatable for credit under different titles.

EENG598. SPECIAL TOPICS IN ELECTRICAL ENGINEERING. 6.0 Semester Hrs.

(I, II, S) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once, but no more than twice for the same course content. Prerequisite: none. Variable credit: 0 to 6 credit hours. Repeatable for credit under different titles.

EENG599. INDEPENDENT STUDY. 0.5-6 Semester Hr.

(I, II, S) Individual research or special problem projects supervised by a faculty member, also, 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: 0.5 to 6 credit hours. Repeatable for credit under different topics/ experience and maximums vary by department. Contact the Department for credit limits toward the degree.

EENG600. GRADUATE SEMINAR ON SMART-GRID ELECTRICAL POWER AND ENERGY SYSTEMS. 3.0 Semester Hrs.

(I, II, S) In this course, learners will plan, develop, and present a research project in their field of technology on a subject related to Smart-Grid, Electrical Power, and Energy Systems. Their chosen topic and seminar must demonstrate their knowledge and skills in scientific and engineering analysis and modeling, project handling, technical writing, problem-solving, evaluation and assessment of their goals, and oral presentation techniques. Learners will advance their research training in the design of future electric power grids, conduct analysis, simulation and data evaluation of electricity infrastructure in the area of Smart Cities, prosumers and distributed generation and will attend and make seminar or another modern presentation on cutting-edge issues of enhanced livability, enhanced workability, and increased sustainability for Transportation and Electrification, Power System Resiliency, Energy Economy, Community Micro-grids, Data Analytics, and Renewable Energy. 3 hours lecture; 3 semester hours.

Course Learning Outcomes

- Advance their research training in the design of future electric power grids with high penetration of renewable energy and electrical energy storage
- Conduct analysis, simulation and data evaluation of electricity infrastructure in the area of Smart Cities, prosumers and distributed generation
- Prepare and make a seminar presentation in a very dynamic and modern format on cutting edge issues of enhanced livability, enhanced workability, and enhanced sustainability for Transportation and Electrification, Power System Resiliency, Energy Economy, Community, Micro-grids, Data Analytics, and Renewable Energy
- Communicate (in oral and written formats) results to a both a technical as well as a non-technical audience

EENG617. INTELLIGENT CONTROL SYSTEMS. 3.0 Semester Hrs.

Fundamental issues related to the design on intelligent control systems are described. Neural networks analysis for engi neering systems are presented. Neural-based learning, estimation, and identification of dynamical systems are described. Qualitative control system analysis using fuzzy logic is presented. Fuzzy mathematics design of rule-based control, and integrated human-machine intelligent control systems are covered. Real-life problems from different engineering systems are analyzed. Prerequisite: EENG517. 3 hours lecture; 3 semester hours. Taught on demand.

EENG618. NONLINEAR AND ADAPTIVE CONTROL. 3.0 Semester Hrs.
This course presents a comprehensive exposition of the theory of nonlinear dynamical systems and the applications of this theory to adaptive control. It will focus on (1) methods of characterizing and understanding the behavior of systems that can be described by nonlinear ordinary differential equations, (2) methods for designing controllers for such systems, (3) an introduction to the topic of system identification, and (4) study of the primary techniques in adaptive control, including model-reference adaptive control and model predictive control. Offered on demand. Prerequisite: EENG517.

EENG683. COMPUTER METHODS IN ELECTRIC POWER SYSTEMS. 3.0 Semester Hrs.
This course deals with the computer methods and numerical solution techniques applied to large scale power systems. Primary focus includes load flow, short circuit, voltage stability and transient stability studies and contingency analysis. The details include the modeling of various devices like transformer, transmission lines, FACTS devices, and synchronous machines. Numerical techniques include solving a large set of linear or non-linear algebraic equations, and solving a large set of differential equations. A number of simple case studies (as per IEEE standard models) will be performed. Prerequisites: EENG583, EENG580 and EENG582 or equivalent; a strong knowledge of digital simulation techniques. 3 lecture hours; 3 semester hours. Taught on demand.

EENG698. SPECIAL TOPICS IN ELECTRICAL ENGINEERING. 6.0 Semester Hrs.
(I, II, S) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once, but no more than twice for the same course content. Prerequisite: none. Variable credit: 0 to 6 credit hours. Repeatable for credit under different titles.

EENG699. INDEPENDENT STUDY. 0.5-6 Semester Hr.
(I, II, S) Individual research or special problem projects supervised by a faculty member, also, 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: 0.5 to 6 credit hours. Repeatable for credit under different topics/ experience and maximums vary by department. Contact the Department for credit limits toward the degree.

EENG707. GRADUATE THESIS / DISSERTATION RESEARCH CREDIT. 1-15 Semester Hr.
(I, II, S) Research credit hours required for completion of a Masters-level thesis or Doctoral dissertation. Research must be carried out under the direct supervision of the student's faculty advisor. Variable class and semester hours. Repeatable for credit.

Professor and Department Head

Peter Aaen

Professors

Atef Elsherbeni

Kathryn Johnson

Tyrone Vincent

Michael Wakin

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