ELECTRICAL ENGINEERING (EENG)

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.
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. 3 hours lecture; 3 hours lab; 4 semester hours. Prerequisite: PHGN200.
Course Learning Outcomes

- ABET outcomes A, B , E, G and K

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.
Course Learning Outcomes

- Unchanged

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 or MATH235.
Course Learning Outcomes

- Unchanged

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. Prerequisite: EENG281 or EENG282 or PHGN215 (C- or better), MATH225 or MATH235. Co-requisite: EENG 391.
Course Learning Outcomes

- Compute and interpret the spectrum of continuous and discrete-time signals
- Determine the effect of converting between continuous and discrete-time signals, and choose sampling rates using the guidelines of the Nyquist sampling theorem
- Determine the response of a discrete time system using convolution, z-transforms, or frequency response techniques
- Determine the response of a continuous time system using convolution, Fourier Transforms or frequency response techniques
- Use MATLAB to analyze and implement digital filters

EENG311. INFORMATION SYSTEMS SCIENCE II. 3.0 Semester Hrs.
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.
Course Learning Outcomes

- 1. Students will learn how to characterize information and noise in electrical systems.
- 2. Students will be able to apply probability concepts, such as Bayes rule to electrical systems.
- 3. Students will be able to apply statistical concepts, such as construct a confidence interval for a parameter estimate to electrical systems.
- 4. Students will be able to compute the probability of detecting signals in noise.

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.
Course Learning Outcomes

- ABET outcome b, c, e, g, i and k

EENG383. EMBEDDED SYSTEMS. 4.0 Semester Hrs.
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).
Course Learning Outcomes

- Unchanged

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.
Course Learning Outcomes

- Unchanged

EENG386. 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. Prerequisite: EENG281 (C- or better) or EENG282 (C- or better), and MATH225 or MATH235.
Course Learning Outcomes

- Unchanged

EENG389. FUNDAMENTALS OF ELECTRIC MACHINERY. 4.0 Semester Hrs.
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.
Course Learning Outcomes

- Unchanged

EENG390. ENERGY, ELECTRICITY, RENEWABLE ENERGY, AND ELECTRIC POWER GRID. 3.0 Semester Hrs.
(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.
Course Learning Outcomes

- ABET A-K

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 or PHGN215 (C- or better), MATH225 or MATH235. Co-requisite: EENG310.

Course Learning Outcomes

- Create and plot signals and data using MATLAB
- Use MATLAB to analyze and implement digital filters
- Use MATLAB and Simulink for integration, differentiation, and simulation of dynamical systems

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

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.

Course Learning Outcomes

- Students will be able to write and present a report that describes a contemporary product or process and how signal processing, control and/or instrumentation enables this product or process.
- Students will be able to utilize documentation and web resources develop signal processing, control and instrumentation applications using state of the art software and hardware
- Students will be able to describe the societal impact of current signal processing, control, instrumentation, and robotics applications.

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

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. 1 hour lecture; 2 hours lab; 1 semester hour. Prerequisite: EENG383 or EENG385.

Course Learning Outcomes

- Students are expected to embrace the philosophy that in complex PCB design
- Making trade-offs between competing, and often conflicting, goals.

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.

Course Learning Outcomes

- 1) learn how to select different antennas to meet the design requirements and application
- 2) perform detailed design analysis in the context of electromagnetic simulation
- 3) establish and develop error analysis associated with the design through simulation
- 4) fabricate simple antennas and passive microwave devices
- 5) perform the basic measurements in an antenna lab
- 6) write a professionally acceptable technical report.

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.

Course Learning Outcomes

- 1. Students will successfully complete a research project under direction of a member of the departmental faculty.

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.

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.

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.

Course Learning Outcomes

- LO1: Describe sources and types of data in modern energy and automation systems

- LO2: Apply R commands to analyze data and develop data analytics models
- LO3: Apply statistical analysis tools to process raw data
- LO4: Derive statistical inferences about a population
- LO5: Assign data instances to classes
- LO6: Apply regression techniques to model the relationship among variables of interest
- LO7: Design artificial neural networks for various prediction applications
- LO8: Evaluate the performance of a developed model using appropriate metrics

EENG417. MODERN CONTROL DESIGN. 3.0 Semester Hrs.
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.
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.
Course Learning Outcomes

- Explain what a semiconductor is and how to change its properties (through doping, application of a voltage potential, etc.)
- Use a band diagram to explain how a pn junction diode works
- Describe how innovations in semiconductor devices (the integrated circuit, high efficiency white LEDs, improved solar cells) have changed our world (modern computing, energy efficiently lighting, alternative energy).
- Identify the idealities in device models and understand their limitations
- Apply the concepts learned in class to the design of novel devices or improvement of an existing device
- Characterize the difference between devices of the same “family” (BJTs vs. MOSFETS, lasers vs. LEDs vs. photovoltaics)
- Explain concepts to a broad audience through varied forms (written, multimedia, etc.)

EENG423. INTRODUCTION TO VLSI DESIGN. 3.0 Semester Hrs.
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.
Course Learning Outcomes

- Derive an ideal model for the MOSFET relating current and voltage
- Communicate effectively about the integrated circuit fabrication process
- Design transistor-level combinational and sequential circuits
- Predict the static and dynamic behavior of digital CMOS systems
- Perform a timing and power analysis on CMOS circuits

EENG425. INTRODUCTION TO ANTENNAS. 3.0 Semester Hrs.
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.
Course Learning Outcomes

- 1. Characterize antenna by their basic properties, such as directivity, polarization, impedance, etc.
- 2. Calculate the properties of dipole and loop antennas.
- 3. Design linear and planar array antennas.
- 4. Characterize the radiation pattern of aperture antennas.
- 5. Design rectangular patch antennas.
- 6. Read an IEEE Antennas and Propagation Society publication and reproduce the results in MATLAB.
- 7. Design, build, and test a simple antenna that operates at 2 GHz.niques
- 8. Design, build, and test a direction finding array. and antenna arrays. This also includes the development of visualization files for the radiation patterns and the input impedance.

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.
Course Learning Outcomes

- 1. Calculate the link budget of a wireless communications system.
- 2. Estimate effects of wireless propagation mechanisms on signals.
- 3. Be able to apply statistical channel models to wireless channels.
- 4. Characterize antenna properties associated with wireless communications.
- 5. Describe, analyze, and understand engineering tradeoffs associated with modulation, coding, multiple access, and spread spectrum techniques.
- 6. Write a paper and present a project on an advanced wireless communications topic not covered in class.

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.

Course Learning Outcomes

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

EENG430. 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. Prerequisites: EENG386. 3 hours lecture; 3 semester hours.

Course Learning Outcomes

- 1. Learn how to analyze and design a variety of passive RF and microwave devices such as filters which will improve the students' ability to identify, formulate, and solve engineering problems.
- 2. Understand the basic operation mechanism of multiport microwave networks systems which will improve the students' ability to apply knowledge of mathematics, science, and engineering in a system level problem.
- 3. Learn how to use vector network analyzers and measure passive microwave devices which will improve the students' ability to apply knowledge of mathematics, science, and engineering.
- 4. Learn how to model passive microwave circuits and devices using a professional CAD tool which will improve the students' ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

EENG433. 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. 3 hours lecture; 3 semester hours. Prerequisite: EENG385 and EENG429 or EENG529.

Course Learning Outcomes

- 1. Learn how to analyze and design a variety of active RF and microwave devices such as power amplifiers which will improve the students' ability to identify, formulate, and solve engineering problems.
- 2. Understand the basic operation mechanism of transmitters and receivers in communication systems which will improve the students' ability to apply knowledge of mathematics, science, and engineering in a system level problem
- 3. Gain a basic understanding on how vector network analyzers operate and how to measure active microwave devices which will improve the students' ability to apply knowledge of mathematics, science, and engineering
- 4. Learn how to model active microwave circuits and devices using a professional CAD tool which will improve the students' ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

EENG437. INTRODUCTION TO COMPUTER VISION. 3.0 Semester Hrs.

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.

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.

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

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.

Course Learning Outcomes

- Unchanged

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.

Course Learning Outcomes

- UNIT #1 – Sources of Renewable Energy (eight modules) -- LO_1: Explain the role of renewable energy sources vs. traditional sources, in the supply of electrical power - Students will write summaries and comparisons
- UNIT #2 – Power Electronics and Poser Systems Conversion (four modules) -- LO_2: Identify the basic design components and their functions for the selected energy conversion devices. Students will work on computational modeling of components and devices.
- UNIT #3 – Energy Storage for Renewable Energy Systems (three modules) -- LO_3: Identify ways to store renewable energy, understand how to use energy storage principles to perform basic system design and component selection for the selected energy storage devices. Students will work on computational modeling of components and devices.
- UNIT #4 – Power Quality and Signal Processing for Grid-Connected versus Stand-Alone Renewable Energy Systems (two modules) -- LO_4: Students will write identification reports of power quality, voltage vs current quality. Students will work on algorithms for signal processing of power quality measurements and improvements. Students will work on implementing algorithms for analysis of power quality using Spreadsheet and/or Matlab scripts.
- UNIT #5 – Final Project Based Learning (two modules) -- LO_5: Whole case study using computational tools. Students will work in pairs, developing a common final project based learning. Students should use all their previous reports, presentations, algorithms, case studies to come-up with a final project. Students will have to use Physics, Mathematics and Engineering Analysis to develop their modeling and control strategies, implement in Matlab, Simulink, PSIM and spreadsheet. Their Final Project will generate a Final Report, plus a Final Presentation.

EENG480. POWER SYSTEMS ANALYSIS. 3.0 Semester Hrs.

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.

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.

Course Learning Outcomes

- 1. Learn how to work with differential and integral forms of Maxwell's equations and plane electromagnetic waves and use them to design electromagnetic devices
- 2. Learn how to build electromagnetic models and use them to solve electromagnetic problems
- 3. Learn how to develop computer programs to visualize electromagnetic fields such as waveguide modes or signal propagation on transmission lines

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.

Course Learning Outcomes

- Students will successfully complete a research project under direction of a member of the departmental faculty.

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.

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.