ELECTRICAL ENGINEERING (EE)

EE 500: Colloquium

1 Credits

Continuing seminars that consist of a series of individual lectures by faculty, students, or outside speakers.

EE 510: Linear Integrated Circuits

3 Credits

Design of monolithic, thin-film, and hybrid linear integrated circuits; D.C., video, tuned, r.f., and microwave applications. Emphasis on reliability.

Prerequisite: E E 410 ; E E 441

EE 518: Neuromorphic Computing

3 Credits

This course delves into developments in the field of brain-inspired neuromorphic computing. The course will offer an interdisciplinary perspective across the computing stack combining insights from machine learning, computational neuroscience to materials, devices, circuits and systems. The course will discuss recent research developments in the field by critiquing publications through presentations and will also provide the opportunity to develop a project focused on a particular layer of the computing stack.

Prerequisite: EE 416 or CMPEN 416

EE 520: Electro Optics--Systems and Computing

3 Credits

Synthetic aperture radar, spatial light modulators, optical interconnection, optical computing, neural networks, and medical optics imaging.

Prerequisite: E E 420

EE 521: Fiber Optics and Integrated Optics

3 Credits

Theories and applications of linear and nonlinear optical phenomena in optical fibers and integrated optical devices.

Prerequisite: E E 421

EE 522: Electro-Optics Laboratory

3 Credits

Basic concepts and fundamentals of light diffraction, optical signal processing, and holography.

Prerequisite: E E 420

EE 524: Lasers and Optical Electronics

3 Credits

Study of several advanced nonlinear optical phenomena, laser propagation, optical and optoelectronic devices, principles, and applications.

Prerequisite: E E 424

EE 526: Nonlinear Optical Materials

3 Credits

Mechanisms of polarization nonlinearity, nonlinear optical processes and analyses, optoelectronic materials and their device application. E E (MATSE) 526 Nonlinear Optical Materials (3) Nonlinear Optical Materials is a course that will generally be offered in spring semesters. It is designed for students who are interested in the materials science-related interdisciplinary electronics/electro-optic engineering areas to provide an essential understanding of the mechanisms of the polarization nonlinearity in electronic materials as well as the principles of operation of these materials in various photonic and optoelectronic applications (e.g., frequency conversion, optical control/communication, and information storage). Analytical methods utilizing the electromagnetic wave theories and tensor operations will be covered in this course to treat anisotropic nonlinear optical materials for their wave-matter interaction processes and to enable device designs. Technological issues in research and development of advanced optoelectronic devices using nonlinear optical materials are discussed with students' participation.Students wishing to take this course should be familiar with optical properties of materials and basic tensor notations.

Prerequisite: E E 420 or MATSE435

EE 531: Engineering Electromagnetics

3 Credits

This course emphasizes advanced electromagnetic field theory concepts, with application to propagation of electromagnetic waves in material media, wave polarization, reflection and transmission of multiple interfaces, and rectangular and circular cross section waveguides and cavities. In this course, students learn electromagnetic theorems and principles with emphasis on induction equivalent and physical equivalent approximations for solution of electromagnetic scattering problems. At the completion of the course, students will be able to apply integral equations and their moment method solutions for practical electromagnetic radiation and scattering problems. The generalized Green's function method will be introduced, including development of closed form Green's functions in rectangular, cylindrical and spherical geometries.

Prerequisite: E E 430

EE 534: Conformal Antennas

3 Credits

Introduction to advanced analysis and design techniques as well as applications for conformal antennas mounted on planar and curved surfaces. E E 534 Conformal Antennas (3) E E 534 provides an introduction to the rapidly growing field of conformal antennas. Analysis and design techniques are presented for conformal antennas mounted on planar as well as curved surfaces. Important applications of conformal antennas are also discussed with emphasis on their recent popularity as wireless PCS, GPS, and body-born antennas. Microstrip antenna design projects will be assigned, where students will gain valuable experience using one or more commercially available industry-standards modeling codes.E E 534 is the third and most advanced course in a three-course sequence of antenna engineering courses: E E 438 (Antenna Engineering, E E 538 (Antenna Engineering) and E E 534.E E 534 will be taught every other fall semester, with an anticipated enrollment of 20-30 students.

Prerequisite: E E 538

EE 535: Boundary Value Methods of Electromagnetics

3 Credits

Theory and application of boundary value problems in engineering electromagnetics; topics include microwave and optical waveguides, radiation, and scattering.

Prerequisite: E E 430 or E E 432 or E E 438 or E E 439

EE 537: Numerical and Asymptotic Methods of Electromagnetics

3 Credits

Finite difference time domain, geometric theory of diffraction and method of moments applied to antennas and scattering.

EE 538: Antenna Engineering

3 Credits

In-depth studies of synthesis methods, aperture sources, broadband antennas, and signal-processing arrays.

Prerequisite: E E 438

EE 541: Manufacturing Methods in Microelectronics

3 Credits

Methods, tools, and materials used to process advanced silicon integrated circuits.

Prerequisite: E E 441

EE 542: Semiconductor Devices

3 Credits

Characteristics and limitations of bipolar transistors, diodes, transit time, and bulk-effect devices.

Prerequisite: E E 442

EE 543: Ferroelectric Devices

3 Credits

Theoretical background of ferroelectric devices, practical materials, device designs, drive/control techniques, and typical applications.

EE 544: Solid-state Mechatronics

3 Credits

This course provides a broad exploration of solid-state mechatronics. Mechatronics deals with solid state devices and systems enabled by piezoelectric effect, electrostatic force, and magnetic and magnetoelectric effect, which are ubiquitous in our society. This course covers key areas of mechatronics, including device fundamentals, key materials, device designs, typical applications and device examples. Applications and devices include solid state actuators and sensors, energy harvesting systems, filters and resonators in wireless communications, transducers in medical imaging and fault detection, and surface acoustic and other guided wave devices in sensing and communications. This course is suitable to graduate students majoring in electrical engineering, mechanical engineering, engineering science and mechanics, and other related fields, who are interested in learning the theory of solid state actuators, sensors, and transducers and designing them for industrial and biomedical applications.

EE 545: Semiconductor Characterization

3 Credits

Physical principles and experimental methods used to characterize the electrical, optical, structural and chemical properties of semiconductor materials.

Cross-listed with: MATSE 545

EE 546: Field-Effect Devices

3 Credits

The physical background, characteristics, and limitations of surface field-effect and junction field-effect devices and related structures.

Prerequisite: E E 442

EE 547: Dielectric Devices

3 Credits

Applications of insulator physics and devices based on insulator properties.

Prerequisite: E E 442

EE 549: Acoustic Wave Devices

3 Credits

Examines materials commonly used for acoustic wave devices, fundamentals of acoustic waves and resonance modes, and characteristics of these devices. E E 549 Acoustic Wave Devices (3)E E 549 is an elective in the field of electronic and photonic materials. Solid state acoustic wave devices based on piezoelectric, ferroelectric, and microelectromechanical systems (MEMS) have a broad range of applications including chemical and biological sensors, electromechanical sensing and transduction, resonators and wave guides for material characterization and health monitoring, filters in telecommunication systems, and optic communications. The course will cover commonly used materials and phenomena for acoustic wave devices, characteristics of different waves and vibration modes, device configurations, their main characteristics and applications, as well as design considerations. Students will learn the key features and materials commonly used for acoustic wave devices, main acoustic mode and their characteristics, important device configurations, the equivalent circuits for acoustic wave modes and devices, and examples of the device applications. Students will also acquire basic skills in selecting acoustic wave devices for specific applications, in designing and characterizing acoustic wave devices for different applications, and in finding suitable available materials and/or phenomena for the acoustic wave device. This course will count as an elective for electrical engineering students in the electronics and photonics sub-discipline. Students wishing to take this course should be familiar with electronic circuit design and solid state devices.

Prerequisite: E E 310 and E E 442

EE 550: Foundations of Engineering Systems Analysis

3 Credits

Analytical methods are developed using the vector space approach for solving control and estimation problems; examples from different engineering applications. E E (M E) 550 Foundations of Engineering Systems Analysis (3) This 3-credit course is offered at the first-year graduate level and provides a systems-theoretic background for more advanced graduate courses in the disciplines of engineering and science. The course uses the vector space approach to develop the analytical foundations for solutions of science and engineering problems in diverse application areas such as optimal control, estimation, and signal processing. First, the theoretical foundation of vector spaces, function spaces, and Hilbert spaces are developed. Linear transformations are then introduced, followed by the Reisz-Frechet theorem and Hahn-Banach theorem, with applications to optimization problems. Spectral analysis is then covered. Finally, diverse applications of these various techniques are presented throughout this course to illustrate the wide range of engineering problems that can be solved using the vector space approach.

Prerequisite: MATH 436
Cross-listed with: ME 550

EE 551: Wavelets and Sparse Signal Representations

3 Credits

Recommended Preparations: Linear algebra This course provides the foundation to understand and use wavelets and sparse signal representations. In particular, it develops sparse representations as an evolution of the discrete wavelet transform. Students will recognize, identify, and apply sparse and wavelet representations methodology to specific signal processing projects. Students will be shown multiple real world applications within this area and guided to apply the methodologies combined with their own domain knowledge.

Prerequisite: EE 453

EE 552: Pattern Recognition and Machine Learning

3 Credits

This course is a comprehensive overview of the fields of pattern recognition and machine learning. The content covers both classification and recursion, model selection, decision theory, information theory, linear and non-linear models, graphical models, kernel methods, mixture models and EM as well as neural networks. It assumes no previous knowledge of pattern recognition or machine learning concepts. Knowledge of multivariate calculus and basic linear algebra is required, and some familiarity with probability would be helpful.

Recommended Preparations: Multivariate calculus, linear algebra, probability
Cross-listed with: CSE 583

EE 553: Topics in Digital Signal Processing

3 Credits

Parametric modeling, spectral estimation, efficient transforms and convolution algorithms, multirate processing, and selected applications involving non-linear and time-variant filters.

Prerequisite: E E 453

EE 554: Topics in Computer Vision

3 Credits

Discussion of recent advances and current research trends in computer vision theory, algorithms, and their applications.

Prerequisite: CMPEN454 or E E 454
Cross-listed with: CSE 586

EE 555: Digital Image Processing II

3 Credits

Advanced treatment of image processing techniques; image restoration, image segmentation, texture, and mathematical morphology.

Prerequisite: CMPEN455 or E E 455
Cross-listed with: CSE 585

EE 556: Graphs, Algorithms, and Neural Networks

3 Credits

Examine neural networks by exploiting graph theory for offering alternate solutions to classical problems in signal processing and control.

EE 557: Multidimensional Signal Processing

3 Credits

Multidimensional sampling, weak causality, recursibility, multidimensional transforms, stability, global and local state-space models, multidimensional filters, and multidimensional spectrum estimation.

Prerequisite: E E 453

EE 559: Wireless and Mobile Sensing in the Age of IoT

3 Credits

This course covers state-of-the-art research on Internet of Things (IoT), with a focus on wireless networking and mobile sensing. Topics of discussion include high precision localization, GPS, smart healthcare, autonomous vehicles and drones, Augmented/Virtual Reality, Battery free communication, 5G basics, Security etc. The course begins with a basic background in linear algebra, signal processing, wireless communications in the context of applications. Thereafter, the topics will be organized into various applications and research from top notch conferences will be presented. In addition, within each application, the appropriate background and common principles underlying Bayesian Filtering, Maximum Likelihood, Sensor design basics etc will be emphasized.

Recommended Preparations: Programming skills are required. Ability to program in any programming language is fine.

EE 560: Probability, Random Variables, and Stochastic Processes

3 Credits

Review of probability theory and random variables; mathematical description of random signals; linear system response; Wiener, Kalman, and other filtering.

Prerequisite: E E 350 ; STAT 418

EE 561: Information Theory

3 Credits

Mathematical measurement of information; information transfer in discrete systems; redundancy, efficiency, and channel capacity; encoding systems.

Prerequisite: E E 460 ; STAT 418

EE 562: Detection and Estimation Theory

3 Credits

Detection decision theory, Bayes and Neyman-Pearson criteria, optimal receivers, classical estimation theory, signal-noise representations, optimum linear signal parameters estimation.

Prerequisite: E E 560

EE 564: Error Correcting Codes for Computers and Communication

3 Credits

Block, cyclic, and convolutional codes. Circuits and algorithms for decoding. Application to reliable communication and fault-tolerant computing.

Prerequisite: Communication Networks
Cross-listed with: CSE 554

EE 565: Reliable Data Communications

3 Credits

Discussion of problems and solutions for ensuring reliable and efficient communication over wired and wireless links and data networks.

Prerequisite: Communication Networks; STAT 418
Cross-listed with: CSE 515

EE 567: Wireless and Mobile Communications

3 Credits

Development of key wireless networks systems analysis and design tools utilizing telecommunications principles; current and emerging mobile wireless techniques. E E 567 Wireless and Mobile Communications (3) E E 567, Wireless and Mobile Communications, extends basic principles ofcommunications systems and their associated performance into the world of wireless and mobile communications. This course has been designed primarily to provide a good understanding of fundamental problems and counter-measure techniques in digital communications over dispersive wireless mobile channels. It starts with a review of material necessary for advanced study in wireless communications: current wireless mobile systems and standards, frequency reuse and the cellular concept, co-channel interference and noise, receiver sensitivity and link budget calculations, coverage, and spectral efficiency and capacity.Next, various types of propagation modeling are presented, such as large-scale fading, small-scale fading, and multiple scattering (multi-path) phenomena. Examples of Rayleigh, Rician, and Nakagami fading channels are discussed, and level crossing rates and fade durations are determined. This is followed by methods for developing laboratory fading channel simulators for both single- and multiple-pathschannel models, including the laboratory simulation of shadowing. Conventional path-loss models in macro-cells such as Okumura-Hata and outdoors micro-cells, COST231-Hata, and Walfish-Ikegami models as well as path loss for indoor micro-cells are then detailed.The next part of the course covers fundamental limits introduced by co-channel interference, as multiple lognormal interferers are introduced. Specifically, Fenton-Wilkinson, Schwartz and Yeh, Farley's methods and a numerical comparison are presented. Outage probability evaluation is detailed. Modulation techniques used in wireless mobile applications and associated performance over fading channels are reviewed next, followed by a detailed investigation of diversity and combining techniques.TDMA and CDMA Cellular systems are presented next. Topics covered here include: Spread spectrum systems including direct sequence, frequency hopping, fading channel applications, RAKE receiver concepts, multi-input-multi-output (MIMO) systems using antenna arrays, space-timecoding and BLAST systems. As examples of mobile cellular architectures,TDMA (GSM) and CDMA cellular systems are covered.Finally, in order to initiate hard or soft handoffs, link quality measurement techniques are discussed. Optimal resource allocation in terms of channel assignment techniques are presented and analyzed.Students will be evaluated by means of assignments (25%), a mid-semesterexamination (35%), and a final examination (40%). The course will be offered every other spring, with an anticipated enrollment of 15-30 students.

Prerequisite: E E 460 ; E E 560

EE 568: Digital Communications I

3 Credits

Linear and nonlinear digital modulation techniques; performance in additive Gaussian noise channel; continuous phase modulation; carrier acquisition and recovery.

Prerequisite: E E 460; Concurrent: E E 560

EE 569: Digital Communications II

3 Credits

Baseband pulse transmission; baseband systems optimization; bandlimited channels performance in ISI; equalization; MLSE and ISI; fading channels; diversity; CDMA.

Prerequisite: E E 560 ; E E 568

EE 573: Constitution of the Ionosphere

3 Credits

Properties of neutral and ionized atmosphere above 60 km; photochemical processes; solar, meteoric perturbations of the ionosphere; large-scale movements in ionization.

EE 574: Propagation Through Random Media

3 Credits

RF/optical wave propagation through turbulent, turbid, and heterogeneous media (atmosphere/ionosphere/sea). Impacts and mitigation discussed for various scenarios.

Prerequisite: E E 430 or E E 439 or E E 477 or PHYS 457

EE 576: Inversion Techniques in Remote Sensing

3 Credits

Introduce skills to address a wide variety of inverse problems such as found in atmospheric sensing, geosciences, and acoustics.

Prerequisite: E E 430 or E E 439 or E E 477 ; STAT 418

EE 578: Radar Systems

3 Credits

This course provides a general understanding of radar systems at the graduate level, building upon material covered in undergraduate courses in electromagnetics, signals and systems, and antenna theory. In particular, it investigates the theory of radar systems and subsystems, and continues with the analysis of the radar equation, target detection in noise, and clutter phenomena. It includes radar techniques to enhance high range resolution of targets such as pulse compression. It also considers radar tracking, synthetic aperture radar, radar polarimetry, target recognition, scattering process, radar signal processing, electronic counter-measure techniques, and laser radar. Building on these concepts, students will understand the usage and applications of various types of radar system designs. Students will understand propagation, multi-path, and clutter phenomena and their effects on radar system performance. Students will recognize, identify, and apply proper radar techniques and apply these techniques to a variety of remote sensing radar applications.

EE 430 and (EE 432; EE 438; EE 439) and (EE 453; EE 460)

EE 579: Microwave Radar Remote Sensing

3 Credits

Scientific and engineering principles of microwave radar remote sensing of land, sea, and the atmosphere.

Prerequisite: E E 430 or E E 438 or E E 439 or E E 473

EE 580: Linear Control Systems

3 Credits

Continuous and discrete-time linear control systems; state variable models; analytical design for deterministic and random inputs; time-varying systems stability.

Prerequisite: E E 380

EE 581: Optimal Control

3 Credits

Variational methods in control system design; classical calculus of variations, dynamic programming, maximum principle; optimal digital control systems; state estimation.

Prerequisite: E E 580

EE 582: Adaptive and Learning Systems

3 Credits

Adaptive and learning control systems; system identification; performance indices; gradient, stochastic approximation, controlled random search methods; introduction to pattern recognition.

Prerequisite: E E 580

EE 584: Robust Control Theory

3 Credits

Fundamentals of Robust Control Theory with emphasis on stability, performance analysis, and design.

Prerequisite: E E 580 or M E 555
Cross-listed with: ME 558

EE 585: Convex Optimization

3 Credits

This course is designed to provide students with necessary skills to recognize or build convex optimization problems coming from diverse application areas and to solve them efficiently. It consists of five parts: 1) convex sets, 2) convex functions, 3) convex optimization, 4) algorithms and 5) real life applications. In the first part, important examples of convex sets will be given and the operations that preserve convexity of sets will be discussed. The second part will focus on convex functions, their basic properties, and the operations that preserve convexity of functions. In the third part, which is built on the first two parts, convex optimization problems will be formally introduced along with important examples ranging from linear and quadratic to semi-definite programming; second, Lagrange duality and optimality conditions will be covered. The fourth part will focus on the algorithms to solve convex problems and on their computational complexity. In the fifth part, various applications will be covered.

Prerequisite: IE 505
Cross-listed with: IE 585

EE 586: Power Systems Dynamics, Stability, and Controls

3 Credits

This course provides a broad exploration of the principles of dynamics, stability, and control of power systems. In particular, it focuses on the angle stability aspect. It will cover dynamic modeling requirements of synchronous generators and dynamic load modeling for stability studies, modeling of generator excitation systems, different types of system stability, modeling and analysis of sub-synchronous oscillations, and some selected special topics relevant to modern power systems. Basic notions of Lyapunov stability will be briefly described. The synchronous generator modeling in rotating d-q-0 frame will be presented along with different degree of simplifications, magnetic saturation models, DC and AC excitation system modeling, and corresponding per unit systems. Integration of such models for stability study of multimachine system will be analyzed. Detailed treatment of small-signal stability analysis for a single-machine-infinite-bus system including the effect of excitation systems and design of power system stabilzers will be presented followed by special techniques to analyze small-signal stability of large-scale multi-machine systems. Numerical integration methods for solving the initial value problem of governing differential and algebraic equations describing power system dynamics will be described in the context of transient stability simulations followed by direct method of transient stability analysis. Fundamentals of subsynchronous oscillations and methods for corresponding stability analysis will be discussed. Finally, dynamic modeling of wind generation and VSC HVDC transmission system will be very briefly introduced.

Prerequisite: EE 488

EE 587: Nonlinear Control and Stability

3 Credits

Design of nonlinear automatic control systems; phase-plane methods; describing functions; optimum switched systems; Liapunov stability; special topics in stability.

Prerequisite: E E 380
Cross-listed with: ME 559

EE 588: Power System Control and Operation

3 Credits

Steady-state and dynamic model of synchronous machines, excitation systems, unit commitment, control of generation, optimal power flow.

Prerequisite: E E 488

EE 589: Smart Grid Control and Dynamics

3 Credits

This course covers the application of advanced power electronics in power apparatus. The ¿rst step is to understand the design of power electronics systems for smart grids.The course starts with an overview of DC/DC converters and covers the controller design for DC/DC converters. Next, voltage source converters and control designs for voltage source converters are covered. Electrical machines are the main components of the smart grid system. Therefore, operation and modeling of AC machines are very important in modern smart grid systems. The additional topics to be covered in this course are: simplified model of an induction machine connected to the grid, modeling and analysis of doubly fed induction generators used in wind farms, modeling and control of permanent magnet synchronous machines, and modeling and analysis of transformers. Next, an overview of mathematical modeling of solar energy systems is provided and different control methodologies are discussed. Next, the state space modeling is covered and the concepts of eigenvalue analysis, Bode plots, and Nyquist stability criterion are implemented to analyze different generation units. Impedance modeling is another technique used to investigate the interactions between renewable energy sources and grids. The basics of impedance modeling technique are covered and case studies are defined to derive the impedance of voltage source converters in smart grids. Dynamic phasor modeling is another technique used to investigate the stability of a dynamic system, especially in unbalanced systems. The main components of dynamic phasor modeling are discussed and an analysis approach is covered to model renewable energy sources in smart grids.

EE 594: Research Projects

1-9 Credits/Maximum of 9

Supervision of individual research projects leading to M.S. or M.Eng. papers. Written and oral reports are required.

EE 596: Individual Studies

1-9 Credits/Maximum of 9

Creative projects including non-thesis research which are supervised on an individual basis and which fall outside the scope of formal courses.

EE 597: Special Topics

1-9 Credits/Maximum of 9

Formal courses given on a topical or special interest subject which may be offered infrequently.

EE 600: Thesis Research

1-15 Credits/Maximum of 999

No description.

EE 601: Ph.D. Dissertation Full-Time

0 Credits/Maximum of 999

No description.

EE 602: Supervised Experience in College Teaching

3 Credits/Maximum of 6

College Teaching Experience

EE 610: Thesis Research Off Campus

1-15 Credits/Maximum of 999

No description.

EE 611: Ph.D. Dissertation Part-Time

0 Credits/Maximum of 999

No description.

EE 897: Special Topics

1-9 Credits/Maximum of 9

Formal course given on a topical or special interest subject with a professional orientation that may be offered infrequently.