ELECTRICAL AND COMPUTER ENGINEERING

Siegel Hall, Suite 103
3301 S. Dearborn St.
Chicago, IL 60616
312.567.3400
gradinfo@ece.iit.edu
engineering.iit.edu/ece

Chair
Jafar Saniie

Faculty with Research Interests
For more information regarding faculty visit the Department of Electrical and Computer Engineering website.

The Department of Electrical and Computer Engineering offers academic programs in advanced study to graduates with technical backgrounds in preparation for careers in industry and in academic research. In addition to the doctoral and master's degrees, which are granted in recognition of research contribution and coursework, the department offers a number of professional master's degrees and certificate programs to enable practicing engineers to pursue continuing education in their areas of interest.

Faculty members are engaged in research in the forefront of their fields, with funding derived from industrial and government research grants and contracts, which provide support to graduate students in the form of research assistantships, in addition to the development and the maintenance of the research facilities. The department also offers a number of fellowships and teaching assistantships on a competitive basis.

Admission to graduate study in one of the programs requires the completion of an undergraduate degree or its equivalent in electrical engineering, computer engineering, or other engineering disciplines from an accredited university. Individuals with backgrounds in other fields of engineering are required to complete courses in the core undergraduate curriculum before commencing graduate work.

For many years, the graduate programs offered by the department have facilitated professionals in industry to advance their knowledge through the pursuit of graduate degrees. The Office of Digital Learning, the interactive distance learning facility of Illinois Institute of Technology, provides support to continuing education by making numerous courses accessible via the Internet and a regional multi-channel television network serving almost 20 industrial organizations in the metropolitan Chicago area.

Research Centers and Facilities
The department operates research laboratories for work in CAD (Computer-Aided Design), for VLSI (Very-Large-Scale Integration), and SoC (System-on-Chip) circuit design, communications, computer networking, wireless networks, network security, cloud computing, cyber physical systems, embedded computing, image processing, medical imaging, data mining, microwave electronics, power systems, smart grids, signal processing, and ultrasonic imaging. The Electric Power and Power Electronics Center supports research initiatives with support from industry and government in the areas of power systems, power electronics, electric machines, motor drives, and vehicular power systems. The Medical Imaging Research Center conducts research in numerous forms for imaging and data analysis, and includes the Advance X-ray Imaging Laboratory (AXIL), which is developing new types of x-ray devices. The department also collaborates with and utilizes the research resources of the Pritzker Institute of Biomedical Science and Engineering and nearby national laboratories.

The department has state-of-the-art computer systems to enhance and extend the generally available system in the university. A primary resource is a network of more than 100 high-performance workstations, file servers, and computer servers, computer clusters for both CPU and GPU (Graphics Processing Unit) based computing, running the Windows/Unix/Linux/OS X operating system. With mass storage, CD-ROM drives, tape drives, and accelerated graphics, these systems provide students and researchers with an array of software tools including: programming languages (C, C++, Java, FORTRAN, Python, Perl, CUDA, Open CL, etc.), software development tools, software and hardware simulators, and electronic computer-aided design packages from companies such as Cadence, Synopsys, Avanti, Synplicity, Xilinx, Altera, Mentor Graphics, EPRI, and ESCA.

In addition to the workstations, the department maintains a collection of PCs for ECE students, including a set of machines that can be dedicated to hardware/software projects. The computers are connected via high-speed Ethernet, (wired and wireless), which in turn is connected to the university's backbone and the Internet.

Research Areas
Active research programs are conducted in the general areas of communications systems, wireless networks, computer systems, computer networks, wireless security, cloud computing and micro-electronics, electromagnetics and electronics, power and control systems, and signal and image processing.
Energy/Environment/Economics (E3)

The Energy/Environment/Economics (E3) program was developed to respond to the rapidly changing needs of the energy industry by providing the interdisciplinary research and training required to produce a new breed of engineer—one who specializes in energy technologies and who understands the associated environmental and sustainability issues and economic forces that drive technology choice.

The E3 specialization requires an interdisciplinary thesis in an E3 area of research for M.S. and Ph.D. degrees, and an interdisciplinary graduate project or additional energy and sustainability courses for professional master's degrees. Graduate students in E3 should also be enrolled in fundamental courses related to the topics of energy, environment, and economics. E3 is designed primarily for students majoring in engineering who are planning careers in energy-related fields. This interdisciplinary training prepares students to be not only creative and expert in a specialized area of energy extraction, conversion, or utilization, but also to possess a broad knowledge base of different energy sources, of sustainability issues related to energy extraction, conversion, and utilization, and of the impact of sustainability principles on the design and operation of energy systems. Furthermore, students will gain sufficient knowledge of sustainability and regulatory issues to enable them to make more viable technology choices.

Admission Requirements

Minimum Cumulative Undergraduate GPA
3.0/4.0

Minimum GRE Scores
- Master's/Master of Science: 304 (quantitative + verbal), 3.5 (analytical writing)
- Ph.D.: 304 (quantitative + verbal), 3.5 (analytical writing)

Minimum TOEFL Scores
80/550 (internet-based/paper-based test scores)

Meeting the minimum GPA and test score requirements does not guarantee admission. Test scores and GPA are just two of several important factors considered. Professional master's degrees in electrical and computer engineering, network engineering, telecommunication and software engineering, power engineering, biomedical images and signals, VLSI and microelectronics, and electricity markets do not require GRE scores for applicants who hold undergraduate degrees from universities in the United States with a minimum cumulative GPA of 3.0/4.0.

Admission to the master's degree programs normally requires a bachelor's degree from an accredited institution in electrical engineering or computer engineering. Applicants with backgrounds in other fields with proficiency in engineering sciences, physics, mathematics, or computer science, gained through prior coursework or professional experience, are also eligible for admission, but will be required to demonstrate proficiency in the subject matter covered in undergraduate courses that are prerequisites for the chosen graduate program.

Proficiency may be demonstrated by passing a written exam or by taking and passing, with a grade of "B" or better, prerequisite undergraduate courses at the university. Specific course prerequisites for each degree program are listed within the program description.

Admission to the doctoral program requires a master's degree. Each entering degree-seeking graduate student is assigned a temporary academic adviser who will provide initial guidance to the candidate. As their research and other academic interests become defined, students may opt to select a new permanent adviser.

Non-degree graduate students should consult with the department adviser. Students are responsible for following the guidelines of the graduate programs set by the department, in conjunction with the regulations of the Graduate College.

Degrees Offered
- Master of Biomedical Imaging and Signals
- Master of Computational Engineering, Optimization, Machine Vision, and Decision Making Track
- Master of Cyber Security Engineering
- Master of Electrical and Computer Engineering
- Master of Network Engineering
- Master of Power Engineering
- Master of VLSI and Microelectronics
- Master of Engineering in Advanced Manufacturing, Automation and Control Systems Track
- Master of Engineering in Energy Systems, Energy Transmission and Markets Track
- Master of Science in Computer Engineering
- Master of Science in Electrical Engineering
• Doctor of Philosophy in Computer Engineering
• Doctor of Philosophy in Electrical Engineering

Dual Degree Program
• Master of Science in Computer Engineering and Electrical Engineering

Joint Degree Programs
• Master of Electricity Markets (with Finance)
• Master of Telecommunications and Software Engineering (with Computer Science)

Interdisciplinary Programs
• Master of Electrical and Computer Engineering with Specialization in Energy/Environment/Economics (E3)
• Master of Science in Electrical Engineering with Specialization in Energy/Environment/Economics (E3)
• Doctor of Philosophy in Electrical Engineering with Specialization in Energy/Environment/Economics (E3)

Certificate Programs
Certificate programs provide a student with post-baccalaureate knowledge in an area of specialization within electrical and computer engineering. Students in these programs register as certificate non-degree seeking students. Certificates are granted upon completion of all course requirements in the chosen specialization area, as listed below, with a minimum GPA of 3.0. Certificate programs must be completed within five years.

It is the student's responsibility to meet all course prerequisites. Any student admitted to a master's degree program offered by the department may apply coursework completed in the certificate program toward the master's degree requirements.

• Advanced Electronics
• Applied Electromagnetics
• Communication Systems
• Computer Engineering
• Control Systems
• Electricity Markets
• Power Electronics
• Power Engineering
• Signal Processing
• Wireless Communications Engineering
Course Descriptions

ECE 502
Basic Network Theory
Lecture: 3 Lab: 0 Credits: 3

ECE 504
Wireless Communication System Design
Fundamentals of first (1G), second (2G), third (3G), and future generation cellular communication systems. This course covers the transition from 1G to 3G systems. Topics included are speech and channel encoders, interleaving, encryption, equalization, modulation formats, multi-user detection, smart antennas, technologies that are used in these transitions, and future generations of cellular systems. Compatibility aspects of digital cellular systems are discussed along with a review of the standards for the industry. TDMA and CDMA systems are covered in detail.
Lecture: 3 Lab: 0 Credits: 3

ECE 505
Applied Optimization for Engineers
Principles of optimization for practical engineering problems, linear programming, nonlinear unconstrained optimization, nonlinear constrained optimization, dynamic programming.
Lecture: 3 Lab: 0 Credits: 3

ECE 506
Analysis of Nonlinear Systems
Graphical and analytical methods, phase plane and singular points, periodic oscillations and limit cycles, forced nonlinear systems, jumps subharmonics and frequency entrainment; stability analysis using Liapunov, Popov and circle criteria; introduction to describing functions.
Lecture: 3 Lab: 0 Credits: 3

ECE 507
Imaging Theory & Applications
Image formation methods including optical (photography), tomography, image formation with arrays of sensors, interferometry, and surface imaging. Technologies of image acquisition including digital cameras, radar/sonar and medical imaging techniques such as magnetic resonance imaging, computed tomography, positron emission tomography, optical imaging, electroencephalography, and magnetoencephalography. Throughout the semester, the course will also focus on the reconstruction of images based on the raw data obtained from various imaging techniques.
Lecture: 3 Lab: 0 Credits: 3

ECE 508
Video Processing and Communications
This course covers the fundamentals of video coding and communications. The principles of source coding for the efficient storage and transmission of digital video will be covered. State-of-the-art video coding standards and error-resilient video coding techniques will be introduced. Recent technologies for robust transmission of video data over wired/wireless networks will be discussed. A detailed overview of architectural requirements for supporting video communications will be presented. Error control and cross-layer optimization techniques for wireless video communications will be covered.
Lecture: 3 Lab: 0 Credits: 3

ECE 509
Electromagnetic Field Theory
Electric and magnetic fields produced by charge and current distributions. Solution of Laplace's and Poisson's equations, time-varying fields and electromagnetic waves. Applications to waveguides and antennas.
Prerequisite(s): ECE 307 with min. grade of C
Lecture: 3 Lab: 0 Credits: 3

ECE 511
Analysis of Random Signals
Probability theory, including discrete and continuous random variables, functions and transformations of random variables. Random processes, including correlation and spectral analysis, the Gaussian process and the response of linear systems to random processes.
Lecture: 3 Lab: 0 Credits: 3

ECE 512
Hybrid Electric Vehicle Drives
Fundamentals of electric motor drives are studied. Applications of semiconductor switching circuits to adjustable speed drives, robotic, and traction are explored. Selection of motor drives, calculating the ratings, speed control, position control, starting, and braking are also covered. Simulation mini-projects and lab experiments are based on the lectures given.
Lecture: 3 Lab: 0 Credits: 3

ECE 513
Communication Engineering Fundamentals
Review of probability and random processes. AM with noise, FM with noise. Introduction to digital communication. Source coding, signal space analysis, channel modulations, optimum receiver design, channel encoding.
Lecture: 3 Lab: 0 Credits: 3
ECE 514
Digital Communication Principles
Information transmission fundamentals, including capacity, entropy, Shannon's theorems and source coding. Introduction to rate distortion theory. Advanced digital modulation and demodulation techniques, performance measures. Channel coding and introduction to trellis coded modulation.
Prerequisite(s): ECE 511 with min. grade of C and ECE 513 with min. grade of C
Lecture: 3 Lab: 0 Credits: 3

ECE 515
Modern Digital Communications
Review of modulation and coding. Trellis coded modulation. Digital signaling over fading multipath channels. Spread spectrum signals for digital communications. Multiple access systems, time-division multiple access, code-division multiple access, and frequency-division multiple access. Advanced communications systems.
Prerequisite(s): ECE 511 with min. grade of C and ECE 513 with min. grade of C
Lecture: 3 Lab: 0 Credits: 3

ECE 516
Coding for Distributed Storage Systems
Distributed storage systems, such as data centers, are becoming a vital infrastructure of today's society by allowing to store reliably large amounts of data and make it accessible anywhere and anytime. The goal of this course is to train students with the different mathematical and engineering tools that are needed when studying and designing codes and algorithms for data reliability and security in these large-scale systems. The course will cover relevant topics in information theory, coding theory, graph theory, and wireless communications in addition to the active on-going research in this area.
Prerequisite(s): ECE 511 with min. grade of C
Lecture: 3 Lab: 0 Credits: 3

ECE 517
Modern Wireless Network Protocols and Standards
This course introduces cutting-edge wireless networking technologies with focus on the network protocols and standards of the current and next generation wireless networks including cellular networks, wireless local area networks, and wireless ad hoc networks. Specifically, it will cover topics relevant to wireless communications, radio resource management, mobility management, wireless medium access control, wireless routing protocols, and wireless TCP protocols.
Prerequisite(s): ECE 407 with min. grade of C or ECE 408 with min. grade of C
Lecture: 3 Lab: 0 Credits: 3

ECE 518
Computer Cyber Security
This course covers topics such as network-related security threats and solutions, private- and public-key encryptions, authentication, digital signatures, Internet Protocol security architecture (IPSEC), firewalls, network management, wireless network security, email, and web security.
Lecture: 3 Lab: 0 Credits: 3

ECE 519
Coding for Reliable Communications
Encoders and decoders for reliable transmission of digital data over noisy channels. Linear block codes, cyclic codes, BCH codes, convolutional codes. Burst error correcting codes. Maximum likelihood decoding of convolutional codes. Performance of block and convolutional codes in additive white Gaussian channel.
Lecture: 3 Lab: 0 Credits: 3

ECE 520
Information Theory and Applications
Definition of information; coding of information for transmission over a noisy channel including additive Gaussian noise channels and waveform channels; minimum rates at which sources can be encoded; maximum rates at which information can be transmitted over noisy channels. Information theoretic security. Modern applications of information theory in communications, networking, and other fields.
Prerequisite(s): ECE 511 with min. grade of C
Lecture: 3 Lab: 0 Credits: 3

ECE 521
Quantum Electronics
Prerequisite(s): ECE 307 with min. grade of C
Lecture: 3 Lab: 0 Credits: 3

ECE 522
Electromagnetic Compatibility
Prerequisite(s): ECE 307 with min. grade of C
Lecture: 3 Lab: 0 Credits: 3

ECE 523
Fundamentals of Semiconductor Devices
The goals of this course are to give students an understanding of the physical and operational principles behind important electronic devices. Semiconductor electron and hole concentrations, carrier transport, and carrier generation and recombination are discussed. P-N junction operation and its application to diodes, solar cells, and LEDs, are developed. The metal-oxide-semiconductor-field-effect transistor (MOSFET) and bipolar junction transistor (BJT) are then discussed. Applications of transistors in analog and digital circuits are introduced. A term project on a particular device topic is required.
Lecture: 3 Lab: 0 Credits: 3
Lecture:

and Internet of Things using Agile software engineering practices. web application with server back-end that connects mobile devices. Programming projects will include the development of a data-rich database integration, RESTful service, and data visualization. include systems development life cycle, client-server architectures, include Java, Python, SQL, and JavaScript. Key topics covered (SaaS) for electrical and computer engineers. Languages addressed for application software development utilizing Software as a Service. The course provides introduction to languages and environments for application software development utilizing Software as a Service (SaaS) for electrical and computer engineers. Languages addressed include Java, Python, SQL, and JavaScript. Key topics covered include systems development life cycle, client-server architectures, database integration, RESTful service, and data visualization. Programming projects will include the development of a data-rich web application with server back-end that connects mobile devices and Internet of Things using Agile software engineering practices. Differential requirement from ECE 448 is a major final project.

ECE 524
Advanced Electronic Circuit Design
RF amplifiers and oscillators. Low and high power RF amplifier design techniques. Stability of amplifiers. LC and crystal oscillators. FM demodulators and limiters. Mixer design. Circuit design to minimize intermodulation and other forms of distortion.
Prerequisite(s): ECE 309 with min. grade of C and ECE 312 with min. grade of C
Lecture: 3 Lab: 0 Credits: 3

ECE 525
RF Integrated Circuit Design
Essentials of contemporary RF CMOS integrated circuit analysis and design. Typical RF building blocks in CMOS and BiCMOS technologies, including passive IC components, MOS transistors, RLC tanks, distributed networks, RF amplifiers, voltage reference and biasing circuits, LNA, mixers, power amplifiers, and feedback networks. RF device modeling. Smith chart applications, bandwidth estimation, and stability analysis techniques. RF IC team design projects.
Prerequisite(s): ECE 312 with min. grade of C
Lecture: 3 Lab: 0 Credits: 3

ECE 526
Active Filter Design
Analysis and design of linear active filters with emphasis on realizations using operational amplifiers. Sensitivity analysis. Switched capacitor filters.
Prerequisite(s): ECE 308 with min. grade of C and ECE 312 with min. grade of C
Lecture: 3 Lab: 0 Credits: 3

ECE 527
Performance Analysis of RF Integrated Circuits
Essentials of analysis techniques for nonlinear effects and noises in contemporary RF integrated circuit design. Nonlinear and distortion behaviors including inter-modulation, cross-modulation, harmonics, gain compression, desensitization, spurious, etc. Noise effects including thermal, short, Flicker, burst noises, etc. RF IC devices and circuits including resistors, capacitors, inductors, diodes, BJTs, FETs, low-noise amplifiers, mixers, power amplifiers, etc. Analysis skills for single-stage and multiple-stage networks. RF IC team design projects.
Prerequisite(s): ECE 312 with min. grade of C
Lecture: 3 Lab: 0 Credits: 3

ECE 528
Application Software Design
The course provides introduction to languages and environments for application software development utilizing Software as a Service (SaaS) for electrical and computer engineers. Languages addressed include Java, Python, SQL, and JavaScript. Key topics covered include systems development life cycle, client-server architectures, database integration, RESTful service, and data visualization. Programming projects will include the development of a data-rich web application with server back-end that connects mobile devices and Internet of Things using Agile software engineering practices. Differential requirement from ECE 448 is a major final project.
Lecture: 3 Lab: 0 Credits: 3

ECE 529
Advanced VLSI Systems Design
Advanced design and applications in VLSI systems. The topics of this course include design tools and techniques, clocking issues, complexity management, layout and floor planning, array structures, testing and testability, advanced arithmetic circuitry, transcendental function approximations, architectural issues, signal processing architecture and sub-micron design. Design projects are completed and fabricated by student teams.
Lecture: 3 Lab: 0 Credits: 3

ECE 530
High Performance VLSI IC Systems
Background and insight into some of the most active performance-related research areas of the field is provided. Issues covered include CMOS delay and modeling, timing and signal delay analysis, low power CMOS design and analysis, optimal transistor sizing and buffer tapering, pipelining and register allocation, synchronization and clock distribution, retiming, interconnect delay, dynamic CMOS design techniques, asynchronous vs. synchronous tradeoffs, BiCMOS, low power design, and CMOS power dissipation. Historical, primary, and recent papers in the field of high-performance VLSI digital and analog design and analysis are reviewed and discussed. Each student is expected to participate in the class discussions and also lead the discussion surveying a particular topic.
Prerequisite(s): ECE 429 with min. grade of C
Lecture: 3 Lab: 0 Credits: 3

ECE 531
Linear System Theory
Prerequisite(s): ECE 308 with min. grade of C
Lecture: 3 Lab: 0 Credits: 3

ECE 533
Robust Control
Uncertain systems; multi-variable control design; linear fractional transformation; uncertainties and small-gain theorem; H-infinity norm; algebraic Riccati equations; H-infinity control; optimality and robustness; design considerations; loop shaping; uncertainty and disturbance estimator; applications and examples.
Prerequisite(s): ECE 438 with min. grade of C
Lecture: 3 Lab: 0 Credits: 3

ECE 535
Discrete Time Systems
Prerequisite(s): ECE 438 with min. grade of C
Lecture: 3 Lab: 0 Credits: 3
ECE 536
Analytical Methods for Power System Economics and Cybersecurity
Prerequisite(s): ECE 319 with min. grade of C or ECE 418 with min. grade of C or ECE 419 with min. grade of C
Lecture: 3 Lab: 0 Credits: 3

ECE 537
Next Generation Smart Grid
Paradigm change of power systems; Challenges faced during the paradigm change; Concept of synchronized and democratized (SYNDEM) smart grids; SYNDEM architecture for next-generation smart grids; Technical routes to implement SYNDEM smart grids; Enabling technologies: Three generations of virtual synchronous machines (VSM); Integration of renewables/EV/storage systems through VSM; Integration of flexible loads through VSM; Illinois Tech SYNDEM prototype smart grid.
Lecture: 3 Lab: 0 Credits: 3

ECE 538
Renewable Energies
Various renewable energy sources such as solar systems, wind powered systems, ocean tides, ocean waves, and ocean thermal are presented. Their operational principles are addressed. Grid connected interfaces for such systems are explained. Research and Simulation mini-projects with emphasis on either machine design, or power electronic circuit analysis, design, and controls, or grid connected renewable systems are assigned to student groups.
Prerequisite(s): ECE 311 with min. grade of C
Lecture: 3 Lab: 0 Credits: 3

ECE 539
Computer Aided Design of Electric Machines
Fundamentals of energy conversion will be discussed, which are the foundation of efficient design and operation of motors & generators in modern day automotive, domestic and renewable energy systems. It will further investigate the principles of structural assessment, electromagnetic analysis, dimensional and thermal constraints. Finite Element Analysis (FEA) software-based design projects will be used to model the performance and operation of electric machines.
Lecture: 3 Lab: 0 Credits: 3

ECE 540
Reliability Theory and System Implementation
Basic probability and modeling techniques on component, subsystem and system levels. MTBF, MTTR and downtime. Hardware, software and cost considerations. Switching systems. Multicomputer and memory configurations.
Lecture: 3 Lab: 0 Credits: 3

ECE 541
Performance Evaluation of Computer Networks
Introduction to performance evaluation techniques for computer and communication networks. Little’s theorem, birth-death processes, M/G/1 queue, product from queuing networks, approximation techniques for G/G/1 queues and non-product form queuing networks. Discrete event simulations, generation of random variables, variance reduction techniques and general purpose simulation languages.
Lecture: 3 Lab: 0 Credits: 3

ECE 542
Design and Optimization of Computer Networks
This course provides comprehensive introduction to network flows with an integrative view of theory, algorithms, and applications. It covers shortest path, maximum flow, and minimum cost flow problems, including a description of new and novel polynomial-time algorithms. It also covers topics from basic network design to protection and restoration design, to multi-layer network design while taking into account routing and flow requirement as applicable in different network architecture, protocol and technologies.
Prerequisite(s): ECE 407 with min. grade of C
Lecture: 3 Lab: 0 Credits: 3

ECE 543
Computer Network Security
This course introduces network security by covering topics such as network-related security threats and solutions, private- and public-key encryptions, authentication, digital signatures, Internet Protocol security architecture (IPSEC), firewalls, network management, email and web security.
Prerequisite(s): ECE 407 with min. grade of C or ECE 408 with min. grade of C
Lecture: 3 Lab: 0 Credits: 3

ECE 544
Wireless and Mobile Networks
This course provides an overview of different wireless and mobile network standards and systems. The topics covered include cellular networks, satellite networks, wireless local area networks, wireless personal area networks, mobile IP, ad hoc networks, sensor networks, wireless mesh networks and wireless network security.
Lecture: 3 Lab: 0 Credits: 3

ECE 545
Advanced Computer Networks
Prerequisite(s): ECE 407 with min. grade of C or ECE 408 with min. grade of C
Lecture: 3 Lab: 0 Credits: 3
ECE 546
Wireless Network Security
This course focuses on selected research topics current interest in wireless network security. This course will cover security and privacy issues in wireless systems, including cellular networks, wireless LAN, mobile ad hoc networks (MANET), wireless mesh networks, sensor networks, vehicular networks, RFID, and ubiquitous computing.
Prerequisite(s): ECE 434 with min. grade of C
Lecture: 3 Lab: 0 Credits: 3

ECE 547
Wireless Networks Performance Analysis
This course deals with the performance analysis techniques for the main types of wireless networks used today including cellular communication networks, wireless local area networks (WLAN), zigbee wireless networks, and wireless mesh networks. The course not only discusses the details of the related IEEE standards but also focuses on mathematical modeling and analysis to compute the quality of service metrics as well as resource utilization efficiency. Key topics include cellular system design, mobility management, conflict-free medium access, contention-based medium access, Markov chain modeling for 802.11, fixed-point based analysis, 802.15.4 modeling and analysis, and wireless mesh network capacity analysis.
Prerequisite(s): ECE 444 with min. grade of C
Lecture: 3 Lab: 0 Credits: 3

ECE 548
Energy Harvesting
Various harvesting techniques such as solar, ocean ides, vibration, linear motion, radio frequency, passive and active human power generation are presented. Their operational principles are addressed. Research and simulations mini-projects with emphasis on power electronic circuit analysis, design, and controls are assigned to student groups.
Prerequisite(s): ECE 311 with min. grade of C
Lecture: 3 Lab: 0 Credits: 3

ECE 549
Motion Control Systems Dynamics
Fundamentals and applications of motion control systems, control techniques for high precision motion control, state variable feedback of linear and nonlinear systems, multivariable systems, physical system modeling, graphical analysis, and numerical analysis, and system performance analysis.
Prerequisite(s): ECE 438 with min. grade of C
Lecture: 3 Lab: 0 Credits: 3

ECE 550
Power Electronic Dynamics and Control
Modeling an analysis of solid-state switching circuits, parallel module dynamics, multi-converter interactions, resonant converters, feedback control, stability assessment, reduced parts converters, integrated structures, programmable switching regulators, digital switch-mode controllers, and power electronic converter-on-a-chip development.
Prerequisite(s): ECE 411 with min. grade of C
Lecture: 3 Lab: 0 Credits: 3

ECE 551
Advanced Power Electronics
Advanced power electronic converters, techniques to model and control switching circuits, resonant converts, Pulse-Width-Modulation (PWM) techniques, soft-switching methods, and low-voltage high-current design issues are studied. Single-phase and multi-phase, controlled and uncontrolled rectifiers and inverters with different operating techniques and their design and control issues are explained.
Prerequisite(s): ECE 411 with min. grade of C
Lecture: 3 Lab: 0 Credits: 3

ECE 552
Adjustable Speed Drives
Fundamentals of electric machines, basic principles of variable speed controls, field orientation theory, direct torque control, vector of AC drives, induction machines, switched reluctance and synchronous reluctance motors, permanent magnet brushless DC drives, converter topologies of DC and AC drives, and sensorless operation.
Prerequisite(s): ECE 411 with min. grade of C
Lecture: 3 Lab: 0 Credits: 3

ECE 553
Power System Planning
Model development. Interchange capability, interconnections, pooling. Economic generator size and site selection. Concept of reserves, transformers, relays and circuit breakers. Reactive planning AC and DC systems are explored thoroughly from a planning standpoint.
Prerequisite(s): ECE 418 with min. grade of C or ECE 419 with min. grade of C
Lecture: 3 Lab: 0 Credits: 3

ECE 554
Power System Relaying
Principles of relay protection for faults on transmission lines and in transformers, rotating machines and other equipment. Use of over current, differential, distance, wire-pilot, carrier-pilot and microwave-pilot relaying systems. Solid-state relays and computer control of relaying. Determination of short-circuit currents and voltages from system studies.
Prerequisite(s): ECE 418 with min. grade of C or ECE 419 with min. grade of C
Lecture: 3 Lab: 0 Credits: 3

ECE 555
Power Market Operations
Prerequisite(s): ECE 418 with min. grade of C or ECE 419 with min. grade of C
Lecture: 3 Lab: 0 Credits: 3
ECE 556
Power Market Economics and Security
This course covers simulation and scheduling tools used in restructured power system for studying the economics and security of power systems. Topics include modeling of generating units (thermal units, combined-cycle units, fuel-switching/blending units, hydro units, pumped-storage units, photovoltaic, wind), Lagrangian Relaxation-based scheduling, mixed integer programming-based scheduling, and Benders decomposition-based transmission security analyses. The simulation and scheduling tools consider different time scales including on-line security, day-ahead, operational planning, and long-term. The simulation and scheduling tools consider interdependency of supply (such as gas, water, renewable sources of energy) and electricity systems.
Prerequisite(s): ECE 420 with min. grade of C
Lecture: 3 Lab: 0 Credits: 3

ECE 557
Fault-Tolerant Power Systems
Prerequisite(s): ECE 418 with min. grade of C or ECE 419 with min. grade of C
Lecture: 3 Lab: 0 Credits: 3

ECE 558
Power System Reliability
The concept of reliability, reliability indices, component reliability, generation capacity reserve evaluation, transmission system reliability, bulk power system reliability, distributed system reliability, reliability modeling in context.
Prerequisite(s): ECE 418 with min. grade of C or ECE 419 with min. grade of C
Lecture: 3 Lab: 0 Credits: 3

ECE 559
High Voltage Power Transmission
Detailed analysis of transmission and distribution systems. Design of high voltage transmission lines and cables, as well as distribution lines. Flexible AC transmission Systems (FACTS) and high voltage DC links.
Prerequisite(s): ECE 418 with min. grade of C or ECE 419 with min. grade of C
Lecture: 3 Lab: 0 Credits: 3

ECE 560
Power Systems Dynamics and Stability
Prerequisite(s): ECE 418 with min. grade of C or ECE 419 with min. grade of C
Lecture: 3 Lab: 0 Credits: 3

ECE 561
Deregulated Power Systems
Overview of key issues in electric utilities restructuring. Poolco model, bilateral contracts, market power, stranded costs, transmission pricing, electric utility markets in the United States and abroad, OASIS, tagging electricity transactions, electric energy trading, risk in electricity markets, hedging tools for managing risks, electricity pricing, volatility in power markets, and RTO.
Prerequisite(s): ECE 418 with min. grade of C or ECE 419 with min. grade of C
Lecture: 3 Lab: 0 Credits: 3

ECE 562
Power System Transaction Management
Power interchange transaction management in the deregulated electric power industry. Course topics include: power system security assessment, total and available transfer capability (TTC/ATC), transaction management system (TMS), transaction information system (TIS), tagging calculator (IDC), congestion management, transmission loading relief (TLR).
Prerequisite(s): ECE 418 with min. grade of C or ECE 419 with min. grade of C
Lecture: 3 Lab: 0 Credits: 3

ECE 563
Computational Intelligence in Engineering
Introduction to soft computing, fuzzy set theory, neural networks, genetic algorithms, intelligent software agents, comparisons with traditional alternatives, and advanced engineering applications.
Lecture: 3 Lab: 0 Credits: 3

ECE 564
Control and Operation of Electric Power Systems
Unit commitment and application of dynamic programming, fuel budgeting and planning, probabilistic production cost modeling, hydrothermal coordination, power system security and application of expert systems, state estimation, optimal power flow, interchange evaluation and power pools, reactive power planning.
Prerequisite(s): ECE 418 with min. grade of C or ECE 419 with min. grade of C
Lecture: 3 Lab: 0 Credits: 3

ECE 565
Computer Vision and Image Processing
Multidimensional sampling and discrete Fourier transform; Image segmentation; Object boundary (edge) detection and description; shape representation and extraction; Matching and recognition; Image registration; Camera geometry and stereo imaging; Morphological processing; Motion detection and compensation; Image modeling and transforms; Inverse problems in image processing (restoration and reconstruction).
Lecture: 3 Lab: 0 Credits: 3
<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Description</th>
<th>Prerequisite(s)</th>
<th>Lecture:</th>
<th>Lab:</th>
<th>Credits:</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECE 568</td>
<td>Digital Speech Processing</td>
<td>Review of discrete statistical signal analysis. Acoustic aspects of speech and hearing. Digital models of speech production. Short-time processing in time and frequency domains. Waveform encoding and linear predictive coding of speech. Estimation of fundamental speech parameters. Applications including automatic speech recognition and enhancement.</td>
<td>(ECE 437 with min. grade of C and ECE 511 with min. grade of C) or ECE 511 with min. grade of C</td>
<td>3</td>
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<td>3</td>
</tr>
<tr>
<td>ECE 570</td>
<td>Fiber-Optic Communication Systems</td>
<td>Physics of optical fiber, composition, dimensioning, coupling, attenuation, dispersion. Electro-optical conversion devices. (ILDs, LEDs, APDs, PINs). Circuit considerations. Modulation techniques and implications. Overall system considerations. Coherent techniques.</td>
<td>(ECE 312 with min. grade of C and ECE 307 with min. grade of C) or ECE 403 with min. grade of C</td>
<td>3</td>
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</tr>
<tr>
<td>ECE 571</td>
<td>Nanodevices and Technology</td>
<td>Electronic properties and quantum effects. Dielectric, magnetic, and optical properties and their characterizations. Individual nanoparticles and clusters. Carbon nanotubes. Solid disordered nanostructures. Nanostructured crystals. Quantum wells, wires, and dots. Giant magnetoresistance. Material processing techniques. Devices and systems based on nanostructures. Must have successfully passed ECE 307 Electrodynamics or equivalent course.</td>
<td></td>
<td>3 Lab: 0</td>
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<td>3</td>
</tr>
<tr>
<td>ECE 576</td>
<td>Antenna Theory</td>
<td>Plane and spherical waves. Electric and magnetic dipoles. Radiation patterns and impedance characteristics of antennas in free space and over perfect ground. Linear and planar driven antenna arrays. Yagi-Uda parasitic arrays.</td>
<td>ECE 307 with min. grade of C or ECE 421 with min. grade of C or ECE 423 with min. grade of C</td>
<td>3 Lab: 0</td>
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<td>3</td>
</tr>
<tr>
<td>ECE 578</td>
<td>Microwave Theory</td>
<td>Microwave field theory. Propagation, reflection and refraction of plane waves. Anisotropic media. Impedance concept. Hollow, surface-wave and dielectric wave guides. Discontinuities in wave guides. Microwave resonators. Transmission lines. Microwave circuit theory.</td>
<td>ECE 421 with min. grade of C or ECE 423 with min. grade of C</td>
<td>3 Lab: 0</td>
<td></td>
<td>3</td>
</tr>
</tbody>
</table>
ECE 579
Operations and Planning and Distributed Power Grid
The course is divided into four sub-components: current state of the distributed power grid, outlook for the distributed power grid, operation of the distributed power grid, and planning of the distributed power grid. This course will begin by providing an overview of exiting distribution systems and smart grid technologies, such as distribution automation and advanced metering infrastructure (AMI). With the emerging trends in power industry, the course will next focus on trends driving the change and the future components of distributed power grid, including but not limited to distributed generation (DG) and energy storage systems (ESSs). The next part of the course will be focused on the operation and control strategies for distributed power grid systems, including operational constraints, voltage and var control (VVC), and control of DERs and Smart Inverters. The final topic area for the course will be planning of distributed power grid with DERs, including lectures on DER impacts and their assessments, hosting capacity, and microgrid operations.
Lecture: 3 Lab: 0 Credits: 3

ECE 580
Elements of Sustainable Energy
This course covers cross-disciplinary subjects on sustainable energy that relate to energy generation, transmission, distribution, and delivery as well as theories, technologies, design, policies, and integration of sustainable energy. Topics include wind energy, solar energy, biomass, hydro, nuclear energy, and ocean energy. Focus will be on the integration of sustainable energy into the electric power grid, the impact of sustainable energy on electricity market operation, and the environmental impact of sustainable energy.
Prerequisite(s): ECE 418 with min. grade of C or ECE 419 with min. grade of C
Lecture: 3 Lab: 0 Credits: 3

ECE 581
Elements of Smart Grid
This course covers cross-disciplinary subjects on smart grid that relates to energy generation, transmission, distribution, and delivery as well as theories, technologies, design, policies, and implementation of smart grid. Topics include: smart sensing, communication, and control in energy systems; advanced metering infrastructure; energy management in buildings and home automation; smart grid applications to plug-in vehicles and low-carbon transportation alternatives; cyber and physical security systems; microgrids and distributed energy resources; demand response and real-time pricing; and intelligent and outage management systems.
Prerequisite(s): ECE 418 with min. grade of C or ECE 419 with min. grade of C
Lecture: 3 Lab: 0 Credits: 3

ECE 582
Microgrid Design and Operation
Microgrids are the entities that are composed of at least one distributed energy resource and associated loads which not only operates safely and efficiently within the local power distribution network but also can form intentional islands in electrical distribution systems. This course covers the fundamentals of designing and operating microgrids including generation resources for microgrids, demand response for microgrids, protection of microgrids, reliability of microgrids, optimal operation and control of microgrids, regulation and policies pertaining to microgrids, interconnection for microgrids, power quality of microgrids, and microgrid test beds.
Prerequisite(s): ECE 418 with min. grade of C or ECE 419 with min. grade of C
Lecture: 3 Lab: 0 Credits: 3

ECE 583
High Speed Computer Arithmetic
This course covers computer arithmetic as applied to general-purpose and application-specific processors. The focus is on developing high-speed arithmetic algorithms and understanding their implementation in VLSI technology at the gate level. Topics include fixed and floating point number systems, algorithms and implementations for addition, subtraction, multiplication, division, and square root, floating point operations, elementary function approximation, low-power design, error analysis, and interval arithmetic.
Prerequisite(s): ECE 446 with min. grade of C or ECE 485 with min. grade of C
Lecture: 3 Lab: 0 Credits: 3

ECE 584
VLSI Architecture for Signal Processing and Communication Systems
This course aims to convey knowledge of advanced concepts in VLSI signal processing. Emphasis is on the architectural research, design and optimization of signal processing systems used in telecommunications, compression, encryption and coding applications. Topics covered include the principles of datapath design; FIR and IIR filtering architectures; communication systems including OFDM, multirate signal processing; fast transforms and algorithms including fast Fourier transform; discrete cosine transform; Walsh-Hadamard transform; and wavelet transform. Furthermore, advanced computer arithmetic methods including Galois fields, CORDIC, residue number systems, distributed arithmetic, canonic signed digit systems and reduced adder graph algorithms are examined.
Prerequisite(s): ECE 429 with min. grade of C and ECE 437 with min. grade of C
Lecture: 3 Lab: 0 Credits: 3

ECE 585
Advanced Computer Architecture
Design, Analysis and Performance of High-Performance Computer Architectures; High Speed memory Systems; Cache Design and Analysis; Modeling Cache Performance; Instruction Level Parallelism, Cache-only Memory Architectures, Classification of Parallel Architectures; Systolic and Data Flow Architectures; Multiprocessor Performance; and Multiprocessor Iterations.
Lecture: 3 Lab: 0 Credits: 3
ECE 586
Fault Detection in Digital Circuits
Essential elements in testing and testability of digital designs. Automatic tests generation algorithms and fault-simulation methods. Design methodologies to increase testability and decrease test generation costs. Techniques for built-in testing.
Prerequisite(s): ECE 446 with min. grade of C
Lecture: 3 Lab: 0 Credits: 3

ECE 587
Hardware/Software Codesign
Computer-aided techniques for the joint design of hardware and software: specification, analysis, simulation and synthesis. Hardware/software partitioning, distributed system cosynthesis, application-specific instruction set design, interface cosynthesis, timing analysis for real-time systems.
Prerequisite(s): CS 201 with min. grade of C and ECE 441 with min. grade of C
Lecture: 3 Lab: 0 Credits: 3

ECE 588
CAD Techniques for VLSI Design
Overview of techniques and algorithms used in Computer-Aided Design (CAD) for VLSI circuits. Physical CAD tools, including placement, routing, symbolic layout and compaction. High-level CAD tools, including logic synthesis, silicon compilers and high-level synthesis. Recent developments in the field. Design, implementation and performance analysis of prototype CAD tools.
Prerequisite(s): ECE 429 with min. grade of C
Lecture: 3 Lab: 0 Credits: 3

ECE 589
Computer-Aided Design of Analog IC
Analog IC design optimization algorithm such as equation-based optimization and simulation-based optimization algorithms, design automation tools such as harmonic balance, projection-based surface response estimation, shooting methods, etc. will be introduced. Research and mini-projects with emphasis on analog integrated circuit design and optimization algorithms using state-of-the-art tools are assigned to student groups.
Lecture: 3 Lab: 0 Credits: 3

ECE 591
Research and Thesis for Masters Degree
Credit: Variable

ECE 593
Masters Electrical and Computer Engineering Seminar
Seminar course for Master students.
Corequisite(s): ECE 591
Lecture: 1 Lab: 0 Credits: 0

ECE 594
Special Projects
Special projects.
Credit: Variable

ECE 597
Special Problems
Credit: Variable
ECE 719
Theory and Applications of Linear Optimization in Wireless Networks
This short course covers both the fundamental of linear optimization and applications in wireless networking research, emphasizing not only the optimization methodology but also the underlying mathematical structures. In addition to the fundamental contents of simplex method, duality theory, and network flow problems, this course also covers the integer programming techniques. This course discusses the applications of linear optimization in the wireless network, including wireless mesh networks, multi-radio multi-channel networks, and cognitive radio networks.
Prerequisite(s): (ECE 407 with min. grade of C or ECE 408 with min. grade of C) and MATH 477 with min. grade of C
Lecture: 2 Lab: 0 Credits: 2

ECE 721
Introduction to Wireless Cooperative Communications and Applications
The course gives an introduction to wireless cooperative communication networks from the perspective of the channel and physical layer. It discusses cooperative networks protocols and application of these. It will deal with wireless channels and relay networks. Transparent and regenerative physical layer algorithms will be discussed to facilitate the analysis of different architectures. Use of distributed space time codes, multiplexing, and orthogonal frequency division multiplexing will be analyzed to achieve multi-dimensional diversity (path, frequency, and time), reduced interference, and improved QoS.
Prerequisite(s): ECE 403 with min. grade of C
Lecture: 2 Lab: 0 Credits: 2

ECE 735
Cellular Long Term Evolution
Cellular Long Term Evolution (LTE) is a key wireless broadband technology considered as the primary path towards the next generation networks (NGNs). It is generally considered as the dominant wireless technology meeting the seamless, mobile Internet access needs of the upcoming Quadruple Play applications. This short course covers the applications, requirements, architecture, radios and antennas, protocols, network operations and management, and evolution for the LTE technology. Key topics include the functions and interfaces of the protocol layers, Quality of Service (QoS), security, network signaling, infrastructure, user equipment, spectrum, throughput, and coverage. Discussion includes the modulation schemes, frame structure, antenna and radio, and subcarrier and bandwidth allocation methods. End-to-end scenarios on connection setup, interworking with existing 3G cellular, WiFi, and WiMAX networks, and handovers are discussed. Testing and integration issues, limitations, and challenges are also mentioned. Comparative analysis with respect to WiMAX and ultra mobile broadband (UMB) are covered. The likely migration paths from current wireless and wireline networks to LTE and related HSOPA and SAE architectures are discussed.
Lecture: 1 Lab: 0 Credits: 1

ECE 738
Information Technology
Probability and Random Process Information theory addresses information theoretic limits on data compression and reliable data communications in the presence of noise. It has fundamental contribution in communications, networking, statistical physics, computer science, statistical inference, and probability and statistics. It covers entropy, mutual information, fundamental limits on data compression, Huffman codes, channel capacity, and channel coding.
Lecture: 2 Lab: 0 Credits: 2

ECE 739
Broadband Access -- Options and Analysis
This short course deals with requirements, options, architecture, and issues relating to the Next Generation broadband networks. The focus is on the key wireline and wireless access options with specific emphasis on its applicability to multimedia applications. The requirements placed by upcoming services on access are introduced. For the major access options, the key topics include capabilities, architectures, protocol structures, Quality of Service (QoS), security, user equipment, spectrum, throughput, and coverage. The associated signaling and modulation schemes, transport technologies and characteristics, end-to-end scenarios, and interworking are addressed. Comparative analysis in terms of various application profiles involving voice, data, and video are carried out. The modeling techniques for analyzing the interplay and technology and market relevance of xDSL, cable/coax, fiber, WiFi, WiMAX, and cellular wireless options are covered. The likely migration paths for these options towards the Next Generation Networks (NGNs) are mentioned.
Lecture: 2 Lab: 0 Credits: 2

ECE 740
Telecommunication Networks: Requirements to Deployment
The ever-increasing customer demand for new and advanced services and the associated complexities of designing, deploying, optimizing, and managing telecom networks require advanced end to end technology and process expertise. This short course deals with the key concepts of requirements development, design processes, architecture finalization, system design, site testing, performance optimization, and network operations and management of current and upcoming Telecom networks. It provides an overview on how the process works from an idea or concept to productization and will give a view on associated complexities and challenges. Key advances in tools and techniques needed with these major steps are covered. Practical examples of the current and upcoming features which will make telecom networks competitive are addressed. Aspects of customer management, strategies for decision making, and the migration towards future networks are also addressed. Practical examples of networks of selected service providers and how they meet the local and global needs are mentioned.
Lecture: 2 Lab: 0 Credits: 2
ECE 742
Digital System-on-Chip Design
This short course covers digital design techniques and hardware/software realization concepts in embedded computing systems using VHDL. Topics include: basics principles of VHDL programming; designing with FPGA; design of arithmetic logic unit; VHDL models for memories and busses; CPU design; system-on-chip design; efficient hardware realizations of FFT, DCT, and DWT.
Lecture: 2 Lab: 0 Credits: 2

ECE 743
Signal and Data Compression with Embedded Systems
This short course deals with data compression techniques and hardware/software realization concepts in embedded computing systems. Key topics: fundamentals of random signal processing and information theory, compression and decompression processes, lossy and lossless compression methods, compression standards for video and audio, modeling and signal parameter estimation, transform techniques including FFT, DCT, and DWT. Hardware realizations of compression algorithms.
Lecture: 2 Lab: 0 Credits: 2

ECE 744
Embedded Digital Systems for Time-Frequency Distribution, Signal Modeling, and Estimation
This short course deals with time-frequency distribution, signal modeling and estimation, and hardware/software realization concepts in embedded computing systems. Key topics include fundamentals of signal processing and random processes, short-time Fourier transform, split-spectrum processing, Gabor transform, Wigner distribution, Hilbert transform, wavelet transform, cosine transform, chirplet signal decomposition, matching pursuit, parametric time-series frequency estimation, hardware/software codeign and realizations of time-frequency distributions, and signal modeling algorithms.
Lecture: 2 Lab: 0 Credits: 2

ECE 750
Synchrophasors for Power System Monitoring and Control
The course gives an introduction to synchrophasor technology from the perspective of power system monitoring and control. It discusses the fundamentals of measurements and synchrophasor estimation. It covers the IEEE Standard C37.118. Several synchrophasor estimation algorithms will be discussed as they relate to measurement and estimation errors. Various synchrophasor applications will be presented including situational awareness, event detection, model validation, oscillation detection, WAMS, and WAMPAC.
Prerequisite(s): ECE 419 with min. grade of C
Lecture: 2 Lab: 0 Credits: 2

ECE 752
Industrial Applications of Power Electronics and Motor Drives
Practical topologies of different types of power electronic converters are covered including industrial high-voltage and high-current applications, protection, and thermal management. Common industrial motor drives are examined with popular control techniques, simplified modeling, and worst-case design. Regulating and stabilizing methods are applied to switching power supplies, power conditioning systems, electronic ballasts, and electronic motors.
Lecture: 2 Lab: 0 Credits: 2

ECE 754
Power System Protection
This course provides basic understanding of the role of protective relaying in the power system. It also delves into the needs of today’s power systems for protection that is robust and tolerant to heavily loaded transmission systems. The students are challenged to be a part of the solution going forward including the role of wide area system protection.
Lecture: 2 Lab: 0 Credits: 2

ECE 764
Vehicular Power Systems
Conventional electrical power systems of land, sea, air, and space vehicles are detailed along with the scope for improvement. This course covers fundamental attributes of modern EV and HEV powertrains. Fundamentals of power electronic components (Inverters, DC-DC Converters, and Chargers), electric motors and energy storage systems will be presented in the context of EV powertrains. An introduction to EV/HEV operating strategies, battery chargers and controls will also be discussed. Using a combination of power electronic simulations, finite element analysis, hands-on lab experiments and vehicle benchmarking reports, powertrain configurations of popular EV and HEV powertrain components will be analyzed. State of the art, challenges and future trends will be discussed. Low voltage and high voltage systems and advanced distribution system architectures of electric and hybrid electric vehicles will be included. Current trends in the vehicular industry, such as 48V automotive systems and more electric aircraft, will be explained.
Lecture: 2 Lab: 0 Credits: 2
ENGR 502
**Medical Device Regulations and Commercialization**
This course helps prepare students for commercializing medical devices within a highly-regulated environment. Concepts include protecting intellectual property, the structure and scope of the Federal Drug Administration (FDA), developing, testing, producing, and marketing medical devices under FDA regulations, total product lifecycle, and quality management.
Lecture: 3 Lab: 0 Credits: 3

ENGR 510
**Strategic Engineering Management**
This course will review technology-based enterprises and the driving forces that impact corporate strategy. Students will learn how to apply engineering knowledge to determine technology/product direction and make/buy/partnering decisions. Relationships between research and development, operations, finance, marketing, and other functions within engineering-based organizations that drive strategic decisions will be examined. Strategy development and competitive analysis will be included. Case studies from the industry relevant to the student’s engineering track will be reviewed.
Lecture: 3 Lab: 0 Credits: 3

ENGR 520
**Best Practices in Engineering Project Management**
Many engineering projects suffer due to weak business cases, schedule slippages, and cost overruns. This course presents commonly used tools and techniques and best practices to build an effective business case, develop a realistic schedule and budget, and successfully execute and complete a project. Students are introduced to a generic project management life cycle model, review basic project management principles, tools, and techniques, and learn engineering-tailored best practices used by high performing, project-centric organizations. Students have an opportunity to apply selected tools in the form of short classroom exercises.
Lecture: 3 Lab: 0 Credits: 3

ENGR 521
**Risk Management in Engineering Projects**
In project management, a risk is considered an uncertain event that may have a positive or a negative impact on project objectives. Managing identified threats individually through customized strategies is key to project success. Similarly, opportunities must be leveraged for better project outcomes. Implementation of an effective risk management process is imperative for today's complex projects. This course presents a five-step process to manage project threats as well as opportunities. On every project, students will be able to identify and analyze risks and develop response strategies for each identified risk and take proper response action to manage the risks. Industry best practices and quantitative tools and simulations are used to analyze risk.
Lecture: 3 Lab: 0 Credits: 3

ENGR 531
**Urban Systems Engineering Design**
ENGR 531 is a project-based course where students will explore integrated designs of urban systems. Each project will apply the students' engineering disciplines (such as structures, transportation, building science, construction engineering and management, environmental engineering) in a comprehensive analysis that considers the economic, human, and environmental issues associated with the project.
Lecture: 3 Lab: 0 Credits: 3

ENGR 532
**Urban Systems Engineering Seminar**
ENGR 532 is an active seminar course that emphasizes current topics in urban systems engineering. Invited speakers will include researchers and representatives from current practice, such as municipal and regional planners and consultants. Appropriate readings will be assigned in advance of each speaker to guide students in preparation for active discussion with each speaker. Each student will also write a term paper on an urban systems engineering topic of their choice, connecting material from the assigned reading, the speakers, and additional references selected by the student.
Lecture: 3 Lab: 0 Credits: 3

ENGR 534
**Product Design and Innovation**
This course covers all aspects of planning new products or services that are commercially viable and add to a company's suite of offerings. It includes such topics as user research, market analysis, need/problem identification, creative thinking, ideation, concep ting, competitive benchmarking, human factors, prototyping, evaluation, and testing. The course includes creative, analytical, and technical skills in a balanced approach using such teaching methods as case studies, individual exercises, and group projects.
Lecture: 3 Lab: 0 Credits: 3

ENGR 539
**Robotic Motion Planning**
Configuration space. Path planning techniques including potential field functions, roadmaps, cell decomposition, and sampling-based algorithms. Kalman filtering. Probabilistic localization techniques using Bayesian methods. Trajectory planning.
Lecture: 3 Lab: 0 Credits: 3

ENGR 572
**Construction Cost Accounting and Control**
Lecture: 3 Lab: 0 Credits: 3
ENGR 573
Construction Contract Administration
Lecture: 3 Lab: 0 Credits: 3

ENGR 574
Economic Decision Analysis in Civil Engineering
Basic economic concepts including interest calculations, economic comparison of alternatives, replacement decisions, depreciation and depletion, tax considerations, and sensitivity analysis. Evaluation of public projects, the effect of inflation, decision making under risk and/or uncertainty, economic decision models. Case studies from the construction industry.
Lecture: 3 Lab: 0 Credits: 3

ENGR 575
Systems Analysis in Engineering
Management and system concepts, linear programming, graphical methods, Simplex, two-phase Simplex, the transportation problem, the assignment problem, integer programming, and sensitivity analysis. System modeling by activity networks; maximal-low flow, longest-path and shortest-path analyses, flow graphs, decision-tree analysis, stochastic-network modeling, queuing systems, and analysis of inventory systems. Case studies from the construction industry.
Lecture: 3 Lab: 0 Credits: 3

ENGR 576
Nano Manufacturing
This course covers the general methods used for micro- and nano-fabrication and assembly, including photolithography techniques, physical and chemical deposition methods, masking, etching, and bulk micromachining as well as self-assembly techniques. It also covers nanotubes, nanowires, nanoparticles, and the devices that use them, including both electronic and mechanical-electronic systems, as well as nano-structural materials and composites. Focus is on commercially available current processes as well as emerging technologies and evolving research areas. Sensing and instrumentation as well as nano-positioning and actuation are covered briefly.
Lecture: 3 Lab: 0 Credits: 3

ENGR 587
Introduction to Digital Manufacturing
This course is about the digital revolution taking place in the world of manufacturing and how students, workers, managers, and business owners can benefit from the sweeping technological changes taking place. It is about the change from paper-based processes to digital-based processes all through the design/manufacturing/deliver enterprise, and across the global supply chain. It touches on digital design, digital manufacturing engineering, digital production, digital quality assurance, and digital contracting, from large companies to small. There is also a significant focus on cyber security and the new types of threats that manufacturers face in the new digital world. Other topics covered include intelligent machines, connectivity, the digital thread, big data, and the Industrial Internet of Things (IIoT).
Lecture: 3 Lab: 0 Credits: 3

ENGR 588
Additive Manufacturing
This course examines the fundamentals of a variety of additive manufacturing processes as well as design for additive manufacturing, materials available, and properties and limitations of materials and designs. It also examines the economics of additive manufacturing as compared to traditional subtractive manufacturing and other traditional techniques. Additive techniques discussed include 3D printing, selective laser sintering, stereo lithography, multi-jet modeling, laminated object manufacturing, and others. Advantages and limitations of all current additive technologies are examined as well as criteria for process selection. Processes for metals, polymers, and ceramics are covered. Other topics include software tools and connections between design and production, direct tooling, and direct manufacturing. Current research trends are discussed.
Lecture: 3 Lab: 0 Credits: 3

ENGR 592
Engineering Management Capstone Experience
Students apply the knowledge they have acquired in the Engineering Management program to a specific problem or case study. Projects will be identified and mentored in conjunction with faculty and industrial partners. A final report or business plan is required that reflects the focus of the capstone project.
Lecture: 3 Lab: 0 Credits: 3

ENGR 595
Product Development for Entrepreneurs
Elements of product development (mechanical and electrical), manufacturing and production planning, supply chain, marketing, product research, and entrepreneurship concepts are taught in this class. In this course, student teams will be required to create a compelling product that has potential to be sold in today’s marketplace. They will be required to create functional prototypes of their product for people to use and critique. If successful, students will be allowed to put their product on Kickstarter.com and take orders for delivery after the class is complete while potentially fostering their own business as a result of this course.
Lecture: 3 Lab: 0 Credits: 3
**ENGR 596**

**Practical Engineering Training**

This course is a mentored, immersive practical engineering training. Students learn under the direction of professional engineers and practicing engineers by working on real engineering projects. The student will perform hands-on engineering, including learning and developing/applying engineering principles and concepts to complete the project assigned to the student. The student will apply engineering ethics and safety during their practical engineering training. Students will communicate the results of their work in written and oral communications. Students will receive assignments of varying complexity consistent with their graduate standing.

*Lecture:* 0  *Lab:* 9  *Credits:* 3

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**ENGR 598**

**Graduate Research Immersion: Team Project**

This course provides a faculty-mentored immersive team-based research experience. Research topics are determined by the faculty mentor’s area of research. In addition to the mentored research, students participate in seminars, prepare a written report of their research findings, and present their research findings at a poster expo.

*Lecture:* 3  *Lab:* 0  *Credits:* 3

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**ENGR 599**

**Graduate Research Immersion: Individual**

This course provides a faculty-mentored immersive research experience. Research topics are determined by the faculty mentor’s area of research. In addition to the mentored research, students participate in seminars, prepare a written report of their research findings, and present their research findings at a poster expo.

*Lecture:* 3  *Lab:* 0  *Credits:* 3