ECE - Electrical and Computer Engineering

Courses numbered 500 to 799 = *undergraduate/graduate*. (Individual courses may be limited to undergraduate students only.) Courses numbered 800 to 999 = *graduate*.

ECE 577F. Artificial Intelligence for Cyber Physical System (3).
Emphasizes learning algorithms and theory including supervised and unsupervised learning, neural network, reinforcement learning, and applications to cyber physical system. Prerequisite(s): IME 254.

ECE 577G. Introduction to Error Control Coding (3).
Introduces the student to the fundamentals of error-correcting codes and their applications in communications and data storage systems. The goal is to develop the ability to design and analyze classical and modern methods of error-control coding. Prerequisite(s): MATH 511 and IME 254 (or their equivalents).

ECE 577M. Controlled and Autonomous Vehicle Networks (3).
Delves into the foundational concepts and advanced technologies shaping the landscape of Controlled Area Network (CAN) and the transformative field of autonomous and connected vehicles. Students explore the evolution from traditional vehicular communication systems to the sophisticated 5G NR C-V2X technology, gaining insights into the principles, protocols and applications that drive Intelligent Transportation Systems (ITS). The course provides a comprehensive understanding of CAN protocols, their role in vehicular communication, and their integration into autonomous and connected vehicle networks. Prerequisite(s): CS 211. Pre- or corequisite(s): CS 664.

ECE 585. Senior Design Project I (2).
This is the first course in a two-course capstone sequence. The capstone project requires students to design a solution to solve a complex problem. The design should be based on the user's requirements and constraints. Students should design a solution considering alternatives and verify their design meets user requirements. This is a culminating experience, where students must show that they are incorporating the knowledge from electrical/computer engineering (appropriate to the program) prior coursework. Students must incorporate engineering standards and address realistic constraints including but not limited to economic, environmental and safety in their design. Students must work in a group and must attend meetings in person. Typically, this class is taken in the semester prior to the one in which the student is planning to graduate. For undergraduate credit only. Prerequisite(s): senior standing, ECE 492 or ECE 594. Pre- or corequisite(s): PHIL 354 or PHIL 385.

ECE 586. Introduction to Communication Systems (4).
Introduces data communication fundamentals from a signal processing perspective, focusing on the complex pulse amplitude modulation approach used in most commercial wireless systems. Describes specific receiver algorithms (MPAM, MQAM, MPSK, MFSK) for implementing wireless communication links, including synchronization, carrier frequency offset estimation, channel estimation and equalization. While most concepts are presented for systems with single transmit and receive antennas, concludes by extending those concepts to contemporary multiple-input multiple-output (MIMO) systems. Does not require prior courses on analog or digital communication. Prerequisite(s): ECE 383 and either STAT 471 or IME 254. Corequisite(s): ECE 586L.

ECE 594. Microprocessor System Design (4).
Presents knowledge and skills required to design and program microprocessor-based systems. Introduces vendor-supplied special-purpose chips such as interrupt controllers and programmable input/output devices. Laboratory activities give hands-on experience. Prerequisite(s): ECE 238, ECE 394 and IME 254. Corequisite(s): ECE 594L.

ECE 595. Senior Design Project II (2).
This is the second course in a two-course capstone sequence. Students are expected to remain in the same group as Senior Design I. This course focuses on students improving and implementing their solution from Senior Design I (ECE 585) and validating it meets requirements. Students should demonstrate that their solution meets the required engineering standards. A final report must include 1) user requirements and constraints; 2) alternative solutions that were considered during the design phase; 3) engineering standards and how they are incorporated; 4) detailed design process; 5) ethical, environmental, economical and safety considerations in their design; 6) test and validation; 7) budget and build of materials, and 8) reflections, conclusion and future improvements. Students failing this course must retake ECE 585 with a new group. For undergraduate credit only. Prerequisite(s): ECE 585.

ECE 596. Renewable Energy Engineering (3).
Analysis and design of renewable energy systems, including solar, wind, hydroelectric, geothermal and biomass systems. Analysis and design of energy storage systems that integrate with renewable energy systems. Integration of renewable energy systems with the electric power supply system. Prerequisite(s): ECE 282 or APEN 320.

ECE 598. Electric Power Systems Analysis (3).
Analysis of electric utility power systems. Topics include analysis and modeling of power transmission lines and transformers, power flow analysis and software, and introduces symmetrical components. Prerequisite(s): ECE 488.

ECE 684. Introductory Control System Concepts (3).
Introduces system modeling and simulation, dynamic response, feedback theory, stability criteria, and compensation design. Prerequisite(s): ECE 282 and MATH 555, or ECE 383.

ECE 688. Power Electronics (4).
Deals with the applications of solid-state electronics for the control and conversion of electric power. Gives an overview of the role of the thyristor in power electronics application and establishes the theory, characteristics and protection of the thyristor. Presents controlled rectification, static frequency conversion by means of the DC link-converter and the cyclo converter, emphasizing frequency, and voltage control and harmonic reduction techniques. Also presents requirements of forced commutation methods as applied to AC-DC control and firing circuit requirement and methods. Introduces applications of power electronics to control AC and DC motors using new methods such as microprocessor. Prerequisite(s): ECE 383, 488, 492. Corequisite(s): ECE 688L.

ECE 694. High Performance Computer Systems (3).
Introduces modern high performance computer systems that are built using multicore central processing unit (CPU) and many-core graphics processing unit (GPU) architectures. Special attention is given to the cache-memory hierarchy of CPU/GPU and multithreading. Projects focus on contemporary scholarly activities and help students develop teamwork skills. Prerequisite(s): ECE 394 or instructor's consent.

ECE 696. Hardware-Based Cybersecurity (3).
Intended for seniors and graduate students who want to study and explore the role of hardware in improving security for critical systems and sensitive data. Topics covered include elements of computer security, hardware as a cybersecurity solution, physical unclonable function, secure distributed systems, and security engineering. Special attention is given to team-based research activities. Prerequisite(s): ECE 394 or instructor's consent.

ECE 697. Electric Power Systems Analysis II (3).
Analysis, design, modeling and simulation of high-voltage electric power transmission systems and rotating generators. Simulations include short circuit studies, economic dispatch and transient stability. Prerequisite(s): ECE 598.

ECE 707. Machine Learning Essentials and Applications (3).
Presents essential principles, theories and methodologies pivotal to machine learning and its implementations. Important topics include training, development and testing machine learning classification models; analysis of model accuracy considering datasets, bias and variance; and utilization of TensorFlow library for artificial neural networks and deep neural networks. Team activities and projects give hands-on experience. Pre- or corequisite(s): IME 254 and CS 211.

ECE 711. Optimization Techniques for Cyber-Physical Systems (3).
Aims to provide necessary theory and methods to solve optimization problems with the emphasis on cyber and physical systems. Integration of computation, communication and physical systems to improve engineered systems requires understanding of basic optimization techniques and advanced optimization algorithms. Covers basic optimization theory, convex optimization, heuristic optimization techniques, constraint relaxation and applications. Prerequisite(s): MATH 511 and MATH 555; or graduate standing.

ECE 726. Digital Communications Systems I (3).
Presents the theoretical and practical aspects of digital and data communication systems. Includes the modeling and analysis of information sources as discrete processes; basic source and channel coding; multiplexing and framing; spectral and time domain considerations related to ASK, PSK, DPSK, QPSK, FSK, MSK and other techniques appropriate for communicating digital information in both base-band and band-pass systems; intersymbol interference; effects of noise on system performance; optimum systems; and general M-ary digital systems in signal-space. Prerequisite(s): ECE 586 and 754.

ECE 737. Wireless Networking (3).
Cross-listed as CS 737. Covers topics ranging from physical layer to application layer in the wireless and mobile networking fields. Explores physical layer issues of wireless communications, wireless cellular telephony, ad-hoc networks, mobile IP and multicast, wireless LAN (IEEE 802.11), security, Bluetooth and WAP, etc. Imparts general knowledge about wireless communication technologies and ongoing research activities. Prerequisite(s): CS 664.

ECE 754. Probabilistic Methods in Systems (3).
Covers random processes designed to prepare the student for work in communications controls, computer systems information theory and signal processing. Covers basic concepts and useful analytical tools for engineering problems involving discrete and continuous-time random processes. Discusses applications to system analysis and identification, analog and digital signal processing, data compression parameter estimation, and related disciplines. Prerequisite(s): ECE 383 and IME 254.

ECE 777AA. Introduction to Transportation Electrification (3).
Provides an introduction to transportation electrification. Introduces the following vehicle fundamentals, vehicle performance, electric propulsion systems, energy storage and future of transportation electrification.

ECE 777AC. Data-Driven Decisions in Cyber-Physical Systems (3).
An introduction to new cyber-physical systems such as an autonomous vehicle and the smart city, where data has become very important for adaptive operations and with an increased dependence on information and communication technologies (ICT). Topics in the course are focused on new methods in the intersection of computer science and other domains, to support distributed operations, cyber security and processing of data that are generated due to digitalization of these systems (considering that the data can be massive). Prerequisite(s): IME 254 or equivalent.

ECE 777AD. Electric Machines for Transportation Electrification (3).
Focuses on basics of electric motors, placing an emphasis on traction drives. This class covers operating characteristics of synchronous machines, dc machines, brushless DC motors, stepper motors and transient characteristics of machines. This class also introduces electrical safety, protection and motor selection for different applications. Prerequisite(s): ECE 488 or ECE 777AA.

ECE 777AE. Characterization and Modeling of Batteries (3).
Presents a general overview of characterization and modeling of rechargeable lithium-ion batteries for transportation, grid storage, portable and aviation applications. During the course, derivation of mathematical models of the electrochemical dynamics of battery cells, including thermodynamic and kinematic properties at multiple scales, are conducted. Modern lithium-ion chemistries are emphasized. Prerequisite(s): MATH 344, ECE 284 and MATH 555.

ECE 777AF. Controls, Communication and Storage for Transportation Electrification (3).
Presents a general overview of control theory and provides deeper knowledge in control applications such as optimal control and digital control. This course also introduces basic networking and cybersecurity issues related to vehicular communications. Battery maintenance and challenges for grid connection are also introduced in this class. Prerequisite(s): ECE 284, MATH 555, MATH 511.

ECE 777AG. Semiconductor Physics and Devices (3).
Covers the device physics and device applications: fundamentals semiconductor device physics associated with semiconductor devices and in-depth understanding of p/n junction diodes, bipolar junction transistors and junction field effect transistors. Prerequisite(s): PHYS 314, MATH 344.

ECE 777AI. Introduction to Semiconductor Packaging (3).
Explores the intersection of microelectronics, nanoelectronics and semiconductor packaging. Covers the advancement of electronic devices through transistor scaling, with a focus on feature sizes and integrated circuits. Students delve into historical trends, such as Moore's Law, and understand the critical role of packaging in modern electronics. The course details the anatomy and function of semiconductor packages, from substrate-level interconnections to the motherboard, highlighting materials, design and reliability considerations. Prerequisite(s): ECE 477O and ECE 492, or graduate standing.

ECE 777G. Data Communication Analysis I (3).
Presents analysis and practice of data communications. Includes the data channel analysis, e.g., pathloss, shadow fading, outage probability and data cell coverage area. Presents new trend in data modulation and demodulation for terrestrial and satellite communications, e.g., MASK, MPSK, MFSK, MQAM, MAPSK, OFDM in both baseband and bandpass systems. Presents performance analysis of data communications over additive white Gaussian noise (AWGN) and fading channels, e.g., analysis on bit error rate (BER), symbol error rate (SER), packet error rate (PER) and channel capacity such as bandwidth efficiency in bits/second/Hz and outage probability. Prerequisite(s): ECE 586. Pre- or corequisite(s): ECE 754.

ECE 782. Digital Signal Processing (3).
Presents the fundamental concepts and techniques of digital signal processing. Time domain operations and techniques include difference equations and convolution summation. Covers Z-transform methods, frequency-domain analysis of discrete-time signals and systems, discrete Fourier transform, and fast Fourier transform. Emphasizes the frequency response of discrete-time systems and the relationship to analog systems. Prerequisite(s): ECE 383.

ECE 784. Digital Control Systems (3).
Studies the effects of sampling and quantization, discrete systems analysis, sampled-data systems, and Z-domain and state space design. Prerequisite(s): ECE 684 or ME 659.

ECE 790. Independent Study in ECE (1-3).
Arranged individual, independent study in specialized content areas in electrical engineering under the supervision of a faculty member. Repeatable for credit. Prerequisite(s): departmental consent.

ECE 792. Linear Systems (3).
Reviews mathematics relevant to state-space concepts. Formulation of state-variable models for continuous-time and discrete-time linear systems. Concepts of controllability, observability, stabilizability and detectability. Pole placement and observer design. State transformation techniques and their use in analysis and design of linear control systems. Prerequisite(s): ECE 684 or ME 659.

ECE 794. Parallel Computing (3).
Introduces techniques with theory and syntax to program high performance computer systems for data analyses. Particular attention is given to the following areas: multicore/many-core architectures and multithreaded programming using application programming interfaces such as OpenMP, MPI and CUDA. Programming assignments and team projects give hands-on experience. Prerequisite(s): ECE 694 or instructor's consent.

ECE 795. Power System Protection (3).
Talks about the study of power system faults and application of relays for power system protection. Topics include symmetrical components as applied fault currents, current methods and skills to analyze power system under fault conditions, and the knowledge of current technologies of the power system protection for major components. Prerequisite(s): ECE 598.

ECE 796. Electric Power Distribution (3).
Analysis, design, modeling and simulation of radial medium-voltage electric power distribution systems. Simulations include power flow and short circuit. Prerequisite(s): ECE 598.

ECE 826. Digital Communication Systems II (3).
Studies modern digital communication systems. Discusses topics such as carrier and symbol synchronization techniques; fading multipath channels; frequency-hopped spread spectrum systems; smart antenna array systems; space time codes (STC); space-time block codes (STBC); multi-input multi-output (MIMO); orthogonal frequency division multiplexing (OFDM) systems; and multi carrier code division multiple access (MC-CDMA) communications. Prerequisite(s): ECE 726.

ECE 836. 5G and Beyond Wireless Communications (3).
The objective of this course is to learn the fundamental and advanced technologies for fifth generation (5G) and beyond wireless communication systems. This course studies the emerging wireless communications technologies such as massive multiple-input multiple-output (Massive-MIMO) beamforming (BF), millimeter wave (mmWave), frequency mixer intelligent reflecting surface (IRS) antennas, bandwidth efficiency (bits/s/Hz), energy efficient green communications (bits/Joule), etc. Combinations of these technologies may support future explosive higher data rates, lower latency and larger coverage area. Prerequisite(s): ECE 726.

ECE 856. Information Theory (3).
Introduces information theory for students of communication theory, computer science and statistics. Introduces the definitions of entropy, relative entropy and mutual information. Discusses asymptotic equipartition property, entropy rates of a stochastic process, channel capacity, differential entropy and Gaussian channel. Prerequisite(s): ECE 754.

ECE 875. Computer Systems in Data Analytics (3).
Introduces modern computer systems with an emphasis on big data computations and methodologies (such as parallelism and machine learning) necessary for data-driven decision-making. Discusses the future of computing systems and alternative computing technologies. Special attention is given to the following scholarly team activities: technical reading, writing and presentation. Prerequisite(s): ECE 694 or ECE 794, or instructor's consent.

ECE 876. MS Thesis (1-6).
Student-driven research experience to address a specific research question. Potential topics should be formulated by the student and discussed with their advisor. Repeatable for credit. Prerequisite(s): MS thesis advisor's consent.

ECE 877. Special Topics in ECE (2-3).
An umbrella course created to explore a variety of subtopics differentiated by letter (e.g., 877A, 877B). Not all subtopics are offered each semester – see the course schedule for availability. Students enroll in the lettered courses with specific topics in the titles rather than in this root course. Prerequisite(s): departmental consent.

ECE 877AC. Transmission Policy and Planning (3).
Provides a practical approach to fundamentals of power system transmission policy and planning with real-world examples. Covers the regulatory requirements relevant to North America, fundamentals of transmission planning, planning with renewable resources, economic and environmental considerations, and large-scale regional transmission planning. Prerequisite(s): instructor's approval.

ECE 877Q. Data Information Theory (3).
Studies data information theory applicable for data communication analysts and engineers, computer data scientists, and data statistics researchers. First, introduces the definitions of data uncertainty, i.e., data entropy, relative entropy, differential entropy, data processing inequality, data sufficient statistics and data mutual information between Alice and Bob in bits. Second, discusses on data asymptotic equipartition property, data typical sequence and entropy rates of a random process data. Third, presents data channel capacity in bits/s/Hz for channel between Alice and Bob under additive white Gaussian noise (AWGN). Finally, presents data converse to the coding theorem for Gaussian channels. If time permits, discusses data network information theory. Pre- or corequisite(s): ECE 754.

ECE 878. MS Directed Project (1-4).
Project conducted under the supervision of an academic advisor for the directed project option. Requires a written report and an oral presentation on the project. Repeatable for credit. Prerequisite(s): advisor's consent.

ECE 884. Stochastic Controls (3).
Deals with dynamic systems where the input signal as well as the output measurement may be corrupted. Such uncertainty is modeled as an additive random signal at the input as well as the output. Analysis and design of such systems is studied for several system models, including those driven by white Gaussian noise. System response, controllability and observability are studied. Feedback control strategies

are studied for various specifications, including pole placement and cost minimization. Observers and state estimators, including Kalman Filter are studied for cases where the system states may not be available for measurement. Pre- or corequisite(s): ECE 792 and ECE 754, or departmental consent.

ECE 885. Robust Control Systems (3).
When applying control theory to real systems, engineers are faced with uncertainties in plant models, plant disturbances and sensor noise. Robust control theory is an optimal approach for applying feedback control theory to systems with these uncertainties. Students completing this course should be capable of analyzing a linear control system in terms of performance and robustness, designing controllers and estimators using H-infinity optimization, and reducing plant model and/or controller implementation orders. Prerequisite(s): ECE 792; ECE 684 or ME 659.

ECE 886. Error Control Coding (3).
Introduces error control codes, including Galois fields, linear block codes, cyclic codes, Hadamard codes, Golay codes, BCH codes, Reed-Solomon codes, convolutional codes, Viterbi decoding algorithm, Turbo codes and ARQ protocols. Applies to digital 3G and 4G cellular and satellite communications systems. Prerequisite(s): ECE 726.

ECE 892. Power System Dynamics and Stability (3).
Power system dynamics analysis for electric utility power systems. Topics include introduction to power system structures and simulations, fundamentals of electromagnetic transients, dynamic modeling of synchronous machine, excitation system, turbine-governor, interconnected multi-machine, transient stability analysis, linearized modeling and small-signal analysis. Prerequisite(s): ECE 598 or instructor's consent.

ECE 893. Optimal Control (3).
Reviews mathematics relevant to optimization, including calculus of variations, dynamic programming and other norm-based techniques. Formulates various performance measures to define optimality and robustness of control systems. Studies design methods for various classes of systems, including continuous-time, discrete-time, linear, nonlinear, deterministic and stochastic systems. Prerequisite(s): ECE 792.

ECE 895. Power System Reliability (3).
By the end of the semester, students have a good understanding of modeling, analysis and evaluation of power system reliability. Topics covered include Markov process, Monte Carlo simulation, loss of load expectation, energy not served, composite systems modeling, interconnected system reliability modeling and analysis, distribution system reliability analysis (SAIFI, SAIDI etc.), and reliability analysis of dependent smart systems. Prerequisite(s): ECE 697.

ECE 896. Competitive Power Systems Economics and Markets (3).
Aims to introduce graduate students with engineering backgrounds to the operation and planning issues in the deregulated electric power industry, which include basic engineering, optimization and economic concepts relevant to this course, and the operation practices in deregulated power system. Prerequisite(s): ECE 598 or instructor's consent.

ECE 897. Operation and Control of Power Systems (3).
Acquaints electric power engineering students with power generation systems, their operation in economic mode, and their control. Introduces mathematical optimization methods and applies them to practical operating problems. Introduces methods used in modern control systems for power generation systems. Prerequisite(s): ECE 598.

ECE 976. PhD Dissertation (1-16).
Upon receiving doctoral aspirant status student designs and performs research that leads to the PhD degree. Repeatable for credit. Prerequisite(s): admission to doctoral aspirant status.

ECE 981. Cooperative Education (1).
Work-related placement with a supervised professional experience to complement and enhance the academic program. Intended for master's-level or doctoral students in electrical engineering. May not be used to satisfy degree requirements. Repeatable for up to 8 credit hours. Prerequisite(s): departmental consent and a graduate GPA of at least 3.000.

ECE 990. Advanced Independent Study (1-3).
Arranged individual, independent study in specialized content areas in engineering under the supervision of a faculty advisor. Repeatable for credit toward the PhD degree. Prerequisite(s): advanced graduate standing and departmental consent.