ELECTRICAL ENGINEERING

Guru Subramanyam, Department Chairperson

Doctor of Engineering, Electrical Engineering (ELE)

See the Doctoral Degree Requirements section on the School of Engineering page and consult with the department chair.

Doctor of Philosophy in Engineering, Electrical Engineering (ELE)

See the Doctoral Degree Requirements (https://www.udayton.edu/engineering/departments/electrical_and_computer/grad_electrical) section on the School of Engineering page and consult with the department chair.

Master of Science in Electrical Engineering (ELE)

ECE 500	Introduction to the Graduate Program in Electrical and Computer Engineering	0
Core courses:		9
ECE 501	Contemporary Digital Systems	
ECE 503	Random Processes	
ECE 505	Digital Signal Processing	
ECE 506	Microelectronic Devices	
ECE 507	Electromagnetic Fields I	
ECE 509	Analysis of Linear Systems	
Engineering Specialization:		9
Basic Engineering Science:		6
Thesis/Coursework:		6
Total Hours		30

* Only 6 hours of graduate courses can be included as transfer credits.

Certificate in Aerospace Electronic Systems (AEL)

The certificate program curriculum is based on taking 12 credit hours. The student must complete four of the following courses, by taking two courses from Group 1 and two courses from Group 2.

GROUP 1 - Pick 2		
ECE 595 Avionics, Navigation and Guidance		3
ECE 595 Introduction to Radar		3
ECE 532	Embedded Systems	3
GROUP 2 - Pick 2		
ECE 523	Satellite Communications	3
ECE 531	Analog Integrated Circuit Design	3
ECE 545	Automatic Control	3
ECE 573	Photonic Devices & Systems	3
TOTAL HOURS:		12

Courses

ECE 500. Introduction to the Graduate Program in Electrical and Computer Engineering. 0 Hours
Introduction to ECE graduate program, research methods in ECE, technical writing, literature research, ethics, software and resources.

ECE 501. Contemporary Digital Systems. 3 Hours
An introduction to modern digital hardware logic design using a hierarchical system approach including top-down development process. An introduction to alternative design implementation forms including hardware description languages (HDLs) for the design of simple and complex combinatorial logic circuits and sequential logic designs with finite state machines. Good HDL coding practices such as readability, re-configurability, and efficient execution are emphasized along with the use of programmable logic circuits including Field-Programmable Gate Arrays (FPGAs). Required Background: ECE215 or equivalent.

ECE 503. Random Processes. 3 Hours
Random variables as applied to system theory, communications, signal processing and controls. Topics include advanced engineering probability, random variables, random vectors and an introduction to random processes. Required background: ECE 340 or equivalent.

ECE 505. Digital Signal Processing. 3 Hours
A study of one-dimensional digital signal processing, including a review of continuous system analysis and sampling. Topics include z-transform techniques, digital filter design and analysis, and fast Fourier transform processing techniques. Required background: ECE 334 or equivalent course.

ECE 506. Microelectronic Devices. 3 Hours
Crystalline structure of matter, quantum mechanics and energy band theory; bulk properties of semiconductors; p-n and metal-semiconductor junctions; bipolar junction transistors; field-effect transistors; heterostructures; optical properties of semiconductors; devices, modeling and applications. Required background: ECE 304 or equivalent.

ECE 507. Electromagnetic Fields I. 3 Hours
Fundamental concepts, wave equation and its solutions; wave propagation, reflection and transmission; potential theory; construction of modal solutions; various electromagnetic theorems: concept of source, uniqueness, equivalence, induction and reciprocity theorems. Required background: ECE 333 or equivalent.

ECE 509. Analysis of Linear Systems. 3 Hours
State variable representation of linear systems and its relationship to the frequency domain representation using transfer functions and the Laplace transform. State transition matrix and solution of the state equation, stability, controllability, observability, state feedback and state observers are studied.

ECE 510. Microwave Circuits for Communications. 3 Hours
Microwave transmission, planar transmission lines, microwave components and filters. Microwave tubes, microwave communication, radar systems, and electronic support measures. Prerequisite(s): ECE 507.

ECE 511. Antennas. 3 Hours
Fundamental principles of antennas; analysis and synthesis of arrays; resonant antennas; broadband and frequency independent antennas; aperture and reflector antennas; applications to radar and communication systems. Prerequisite(s): ECE 507 or equivalent.

ECE 521. Digital Communications I. 3 Hours
Fundamentals of digital transmission of information over noisy channels; modulation schemes for binary and M-ary digital transmission; optimum receivers; coherent and noncoherent detection; signal design; intersymbol interference; error control coding; the Viberti algorithm; channel capacity and Shannon limits on reliable transmission.

ECE 523. Satellite Communications. 3 Hours
Topics related to the theory, design and orbital placement of geostationary and geosynchronous satellites and their communications applications, including transmitters and receivers in the RF, microwave and optical operational windows, the associated modulation and communication strategies, system hardware and international satellite networks. Required background: ECE 507 or permission from instructor.

ECE 530. Digital Integrated Circuit Design. 3 Hours
Integrated circuit design and layout concepts, design methodology, fabrication process and limitations, MOSFET models for digital design, inverter and logic gates, interconnect and delay, combinational circuits, sequential circuits, datapath subsystems, memory circuits, digital phase lock loops. Required background ECE 304.

ECE 531. Analog Integrated Circuit Design. 3 Hours
Integrated circuit design concepts and layout; system perspective on analog design; MOS device theory and processing technology; current mirrors and biasing circuits; voltage and current references; single-stage, differential and operational amplifiers; CAD utilization to realize the design process. Required background: ECE 304 or equivalent.

ECE 532. Embedded Systems. 3 Hours
This course will introduce the student to the concept of embedded systems and the constraints imposed on hard real-time systems. Course will consist of design, development and test of selected hard-deadline hardware and software using Altera's DE2 development boards. The student will design selected hardware interfaces and develop real-time executive and application code in assembly language and C. Each student will design and implement hardware using Verilog HDL. Required Background: ECE 444 or equivalent.

ECE 533. Computer Design. 3 Hours
Design considerations of the computer; register transfer operations; hardware implementation of arithmetic processors and ALU; instruction set format and design and its effect on the internal microengine; hardware and micro-programmed control design; comparative architectures. Required background: ECE 314 or equivalent.

ECE 536. Microprocessor Applications. 3 Hours
Project studies, applications of microprocessors in practical implementations; logic implementation using software; memory mapped I/O problems and interrupt structure implementation; use of compilers; study of alternate microprocessor families including industrial controllers. Required background: ECE 314 or equivalent.

ECE 538. Object-Oriented Programming Applications. 3 Hours
A semi-formal approach to the engineering applications of object-oriented programming. Application of the concepts of classes, inheritance, polymorphism in engineering problems. Introduction to the use of class libraries. Effective integration of the concepts of application programmer interfaces, language features and class libraries. Required background is C programming experience.

ECE 545. Automatic Control. 3 Hours
Study of mathematical methods for control systems and analysis of performance characteristics and stability. Design topics include pole-placement, root locus, and frequency domain techniques. The student will also learn feedback loop sensitivity, basic loopshaping, performance bounds and other introductory aspects of robust control. Required background is ECE 415 or equivalent.

ECE 547. Non-Linear Systems & Control. 3 Hours
Introduction to nonlinear phenomena in dynamical systems. A study of the major techniques of nonlinear system analysis including phase plane analysis and Lyapunov stability theory. Application of the analytical techniques to control system design including feedback linearization, backstepping and sliding mode control. Prerequisite(s): ECE 509 or permission of instructor.

ECE 563. Image Processing. 3 Hours
An introduction to image processing including the human visual system, image formats, two-dimensional transforms, image restoration, and image reconstruction. Prerequisite(s): ECE 505.

ECE 564. 3D Computer Vision. 3 Hours
Develop the skills needed to generate synthetic images of 3D objects and to recover 3D structure from one or more views (projections) of 3D objects. Feature recognition in 2D views (images) of a scene based either on actual photographs or synthetic images (computer graphics generated). Applications in robot pose recognition and mobile robot navigation. Students should have experience with MATLAB programming and image processing.

ECE 565. Fundamentals of Solid-State Batteries. 3 Hours
Introduction to the fundamental of solid-state, safe, durable, batteries, including working principles of a battery, state-of-the-art battery (Li-ion battery based on liquid-state electrolytes- advantages/disadvantages), battery safety, need for a safe battery system for low-high power applications (electric vehicles / unmanned-/manned aircrafts, space vehicles, etc.), different design of solid-state batteries (planner-stacked, 3 dimensional, etc.), engineering the structural battery (dual functionality system that can carry mechanical load and store energy), characterization methods to evaluate structure / electrical / electrochemical properties of all solid-state battery materials (cathode, anode, electrolytes), interfaces (electrodes/electrolyte), and electrical/ electrochemical testing of complete battery cells. Also, electrical test methods to evaluate solid-state Li-ion battery (including structural battery) performances, etc.), and understanding degradation mechanism of solid-state battery systems (including structural battery) will be discussed. Required background: ECE 304 or equivalent.

ECE 566. Fundamentals of Hybrid Electrochemical Power. 3 Hours
Introduction to the fundamentals of hybrid electrochemical power (battery + capacitor + fuel cell – integrated systems) including working principles of batteries, capacitors, lithium-ion capacitors, and fuel cells. Discussion of the advantages/disadvantages, necessity to hybridize batteries, fuel cells, capacitors. Electrical hybridization methods, electrochemical testing of hybrid power systems, degradation mechanism, and applications. Hybrid electrochemical power is highly desirable to meet requirements for a wide range of products (such as electronic gadgets, transportation vehicles and space vehicles) requiring low to high power/energy, cycle-life, fast/slow charge/discharge, etc. Required background: ECE 304 or equivalent.

ECE 567. Machine Learning & Patterning. 3 Hours
This course introduces the fundamental concepts and models of machine learning with a practical treatment of design, analysis, implementation and applications of algorithms that learn from examples. Topics include supervised and unsupervised learning, self organization, pattern association, feed-forward and recurrent architectures, manifold learning, dimensionality reduction, and model selection. Required background in ECE445 or Graduate Student status.

ECE 568. Detection and Estimation. 3 Hours
This course will provide a fundamental understanding of detection, estimation, and their use in solving engineering problems. Students will be able to solve problems involving hypothesis testing, develop a discrete time signal detector, and compute optimum parameter estimates. Students will become familiar with foundational concepts of likelihood ratio, randomized decision, sufficient statistic, Cramer-Rao bounds, and risk estimation. Students will also develop understanding of linear least square estimation, minimum mean square estimation, minimum mean absolute error estimation, maximum a posteriori estimation, maximum likelihood estimation, minimum variance unbiased estimation, empirical Bayes estimation, and minimum risk shrinkage operator estimation, expectation-maximization algorithm. Prerequisite(s): ECE 503.

ECE 569. Advanced Random Processes. 3 Hours
This course will provide students with a fundamental understanding of probability, random variables and random processes, and their use in solving engineering problems. Students will be able to solve problems involving various noise processes and their probability distributions, describe random signals, and will analyze linear systems with stochastic inputs. Some advanced topics such as Wiener filtering, Kalman filtering, and Karhunen-Loeve decomposition will be covered. Prerequisite(s): ECE 503.

ECE 572. Optical Information Processing. 3 Hours
Mathematical techniques pertaining to linear systems theory; Fresnel and Fraunhoffer diffraction; Fourier transform properties of lenses; frequency analysis of optical systems, spatial filtering, applications such as optical information processing and holography.

ECE 573. Photonic Devices & Systems. 3 Hours
Solid-state theory of optoelectronic devices; semiconductor photoemitters; LED's, optical amplifiers and semiconductor lasers; photodetectors: PIN, APD, photocells, PMT, detection and noise; solar cells; cameras and displays; electro-optic and magneto-optic devices; integration and application of electro-optical components in systems of various types. Prerequisite(s): ECE 507 or permission of department chairperson.

ECE 574. Guided Wave Optics. 3 Hours
Light propagation in slab and cylindrical waveguides; signal degradation in optical fibers; optical sources, detectors, and receivers; coupling; transmission link analysis; fiber fabrication; fiber sensor and communication systems. Prerequisite(s): ECE 507 or permission of department chairperson.

ECE 576. Introduction to Radar. 3 Hours
Introduction to the radar range equation, fields and Waves, antennas and phased arrays, beamforming, targets and clutter radar cross section, fast time, slow time, detection processing, tracking, space-time adaptive processing, FMCW radar, SAR and ISAR, electronic warfare, transmitters, receivers and signal processors. Required background: ECE303, ECE332, ECE340, or equivalent.

ECE 577. Introduction to Electronic Warfare (EW). 3 Hours
Overview of the Principles of Electronic Warfare (EW). Review of radar (and radio frequency communication) systems engineering, including fields and waves, waveforms, antennas and array beamforming, targets detection and image processing, tracking, space-time adaptive processing (STAP), synthetic aperture radar (SAR), Inverse SAR (ISAR). Principles of direction finding (DF), Electronic Attack (EA) of MTI (moving target indication) radar, SAR, and digital radio frequency memory (DRFM). Principles of Electronic Protection (EP) in MTI and SAR. Low Probability of Intercept (LPI) radar and communications, Electronic Intelligence and STAP, Electronic Support Measures (ESM). Required Background: ECE303, ECE332, ECE340, or equivalent. Recommended: ECE576.

ECE 578. Advanced Radar. 3 Hours
Review of the radar range equation, fields and waves, antennas and phased arrays, beamforming, targets and clutter radar cross section, fast time, slow time, detection processing, tracking, frequency modulated continuous wave (FMCW) radar, synthetic aperture radar (SAR) and Inverse SAR (ISAR), electronic warfare (EW), transmitters, receivers and signal processors. Advanced space-time adaptive processing (STAP) techniques, including the Generalized Likelihood Ratio Test, Non-Homogeneity Detection, Knowledge-Based STAP, and Constant False Alarm Rate detection processing. Required Background: ECE303, ECE332, ECE340, ECE512 or equivalent. Recommended: ECE515.

ECE 580. Principles of Nanofabrication. 3 Hours
Basic principles of processes used in microelectronic and photonic device fabrication: vacuum systems, plasma processes, physical and chemical vapor deposition, properties of silicon and other substrate materials, photolithography and non-optical lithography, wet chemical and plasma etching, thermal oxidation of silicon, semiconductor doping, ion implantation, metallization, electrical contacts and micro-metrology.

ECE 581. Nanoelectronics. 3 Hours
Introduction to the physics of materials on the nanoscale; quantum confinement theory; electronic and optical properties of semiconductor nanostructures; single electron transistors (SETs); tunneling and ballistic devices; nanostructured LEDs, photodetectors, and lasers; nanophotovoltaics and nanomagnetics; quantum computing and molecular electronics; nanoelectronic fabrication, state-of-the-art and emerging nanoscale devices and applications. Prerequisite(s): ECE 506 or permission of instructor.

ECE 583. Advanced Photovoltaics. 3 Hours
Science and applications of photovoltaics, with special emphasis on inorganic and organic semiconductors, ferroelectrics, chalcopyrites, metamaterials, quantum structures and photovoltaics archictecture. Prerequisite(s): ECE 506 or permission of instructor.

ECE 586. Computer Networks. 3 Hours
Introduction to the fundamental of computer networks, including the Open Systems Interconnection reference model, transmission media, medium access protocol, data link protocols, routing, congestion control, applications, and network security. Recommended prerequisite: ECE 303.

ECE 587. Wireless Security. 3 Hours
Wireless security is a very important topic and attracting more and more attention from industry, research, and academia. This course gives a comprehensive overview on the recent advances in wireless network and system security. It will cover security issues and solutions in emerging wireless access networks and systems as well as multi-hop wireless networks. Required background: ECE203 or equivalent.

ECE 595. Special Problems in Electrical Engineering. 1-6 Hours
Particular assignments to be arranged and approved by the department chair.

ECE 599. Thesis. 1-6 Hours
Thesis in Electrical and Computer Engineering.

ECE 633. Advanced Computer Architecture. 3 Hours
Examination of modern high performance computing architectures, including out-of-order execution RISC multicore processors and GPGPUs. Design projects integrate the concepts learned in class. Prerequisite(s): ECE 533.

ECE 642. Optimal Control & Estimation. 3 Hours
Introduction to optimal control, starting with dynamic programming for stochastic optimal control; continuous time optimal control, including Pontryagin's Maximum Principle and its application to the linear case, leading to linear optimal control. Prerequisite(s): ECE 509 or permission of instruction.

ECE 645. Adaptive Control. 3 Hours
On-line approximation based adaptive control techniques for nonlinear systems. An introduction to neural networks and fuzzy systems as part of the control loop is given, leading to a diversity of advanced methods for controlling and stabilizing nonlinear systems subject to uncertainties. Adaptive observers and adaptive output feedback are also introduced. Prerequisite(s): ECE 547 or permission of instructor.

ECE 661. Statistical Signal Processing. 3 Hours
This course studies discrete methods of linear estimation theory. Topics include random vectors, linear transformations, linear estimation theory, optimal filtering, least squares techniques, linear prediction, and spectrum estimation. Prerequisite(s): ECE 503, ECE 505.

ECE 682. Nano-Fabrication Laboratory. 3 Hours
This laboratory course will provide hands-on experience in state-of-the-art device fabrication technology. The course will be conducted primarily in a clean room laboratory with some classroom sessions for discussions. The students will have an opportunity to design, fabricate and test their own devices. Prerequisite(s): Permission of instructor.

ECE 695. Special Problems in Electrical and Computer Engineering. 1-6 Hours
Special topics in electrical engineering not covered in regular courses. Course sections arranged and approved by the chair of the student's doctoral advisory committee and the department chair.

ECE 696. Graduate Seminar. 0-3 Hours
Research oriented independent study course intended for doctoral level graduate students. The student will perform an in-depth research on a selected topic of mutual interest with his/her doctoral adviser, and achieve sufficient expertise to do a technical presentation about the topic in front of his/her peers. The student will prepare a report and present it in one of the graduate seminar sessions during the semester. The student is expected to attend all the seminars presented by other graduate students during the semester and to interact with them to improve the depth and breath of his/her knowledge.

ECE 699. PhD Dissertation. 1-15 Hours
Original research in electrical engineering that makes a definite contribution to technical knowledge. Results must be of sufficient importance to merit publication in a refereed journal.