

SCHOOL OF ELECTRICAL AND COMPUTER ENGINEERING

Electrical engineers have defined, shaped, and driven the information technology revolution that we are experiencing today. Building on the fundamental cornerstones of electrical engineering—the control of information and electric power—electrical engineers have been responsible for innovations and technological breakthroughs that have altered the fabric and face of modern life. Cell phones, tablets, modern hearing aids, the Internet, digital cameras, global positioning systems, and hybrid cars all are based on electrical engineering. Georgia Tech's School of Electrical and Computer Engineering (ECE) is consistently ranked nationally among the top ten of all electrical engineering programs, and its graduates are pioneering such life-altering innovations as biomedical devices that save lives, and improve everyday living for disabled people, as well as environmentally friendly technologies such as solar energy and wind power. The electrical engineering program encompasses all major areas of this dynamic field, including analog electronics, bioengineering, digital signal processing, electric power, electromagnetics, microelectronics and microsystems, nanosystems, optics and photonics, systems and controls, and telecommunications.

Combining the study of computer systems with traditional aspects of electrical engineering, computer engineering is one of the fastest growing fields in the country, with projected demand over the next decade expected to grow by as much as 150 percent. The computer engineering program in ECE is at the forefront of this new and dynamic field, with national rankings consistently in the top ten. Rapid advances in underlying technologies have resulted in ever smaller, less costly, and higher-performance computer systems, making computers omnipresent in our everyday lives and fueling exciting developments in areas like robotics, wired and wireless networking, embedded processing, network security, and data storage. It is this ever-expanding capacity of computers that empowers us to communicate, learn, transact business, receive medical treatment, and explore space in new ways.

The School of Electrical and Computer Engineering (ECE) provides undergraduate and graduate programs that prepare students to participate in a broad range of career opportunities. Modern facilities and laboratories support experimental and theoretical programs of instruction and research. Additional information about the School is available at <https://ece.gatech.edu/> or upon request by calling 404.894.2901.

Bachelor's Degrees

- Bachelor of Science in Computer Engineering
- Bachelor of Science in Electrical Engineering

Master's Degrees

- Master of Science in Bioengineering
- Master of Science in Computational and Science Engineering
- Master of Science in Electrical and Computer Engineering
- Master of Science in Robotics
- Professional Master's in Sustainable Electrical Energy (PMSEE)

Doctoral Degrees

- Doctor of Philosophy with a Major in Bioengineering
- Doctor of Philosophy with Major in Computational Science and Engineering

- Doctor of Philosophy with a Major in Electrical and Computer Engineering
- Doctor of Philosophy with a Major in Machine Learning
- Doctor of Philosophy with a Major in Robotics
- Joint Doctor of Philosophy with a Major in Electrical and Computer Engineering with the Politecnico di Milano
- Joint Doctor of Philosophy with a Major in Electrical and Computer Engineering with the Politecnico di Torino (Italy)

ECE 1010. Introduction to ECE Design. 2 Credit Hours.

An introduction to basic concepts useful for all areas of Electrical and Computer Engineering. Focus on hands-on, team-based activities using robotics.

ECE 1100. ECE Discovery Studio. 1 Credit Hour.

Students will explore ECE curriculum threads and opportunities available during the undergraduate experience while navigating the early career planning process.

ECE 1801. Special Topics. 1 Credit Hour.

ECE 1802. Special Topics. 2 Credit Hours.

ECE 1803. Special Topics. 3 Credit Hours.

ECE 1804. Special Topics. 4 Credit Hours.

ECE 1805. Special Topics. 5 Credit Hours.

ECE 1811. Special Topics. 1 Credit Hour.

ECE 1812. Special Topics. 2 Credit Hours.

ECE 1813. Special Topics. 3 Credit Hours.

ECE 1814. Special Topics. 4 Credit Hours.

ECE 1815. Special Topics. 5 Credit Hours.

ECE 1871. Special Topics. 1 Credit Hour.

Special Topics for Electrical and Computer Engineering.

ECE 1881. Special Topics. 1 Credit Hour.

ECE 1882. Special Topics. 2 Credit Hours.

ECE 1883. Special Topics. 3 Credit Hours.

ECE 1884. Special Topics. 4 Credit Hours.

ECE 1891. Special Topics. 1 Credit Hour.

ECE 1892. Special Topics. 2 Credit Hours.

ECE 1893. Special Topics. 3 Credit Hours.

ECE 1894. Special Topics. 4 Credit Hours.

ECE 1900. Special Problems. 1-21 Credit Hours.

ECE 1901. Special Problems. 1-21 Credit Hours.

ECE 1902. Special Problems. 1-21 Credit Hours.

ECE 1903. Special Problems. 1-21 Credit Hours.

ECE 1XXX. Electrical and Computer Engineering Elective. 1-21 Credit Hours.

ECE 2001. ECE Seminar. 1 Credit Hour.

Speakers with diverse backgrounds and representing many different industries, professions, and institutions describe their experiences, entrepreneurial ventures, and research challenges.

ECE 2002. ECE Seminar. 1 Credit Hour.

Speakers with diverse backgrounds and representing many different industries, professions, and institutions describe their experiences, entrepreneurial ventures, and research challenges.

ECE 2003. ECE Seminar. 1 Credit Hour.

Speakers with diverse backgrounds and representing many different industries, professions, and institutions describe their experiences, entrepreneurial ventures, and research challenges.

ECE 2020. Digital System Design. 3 Credit Hours.

Computer system and digital design principles. Switch and gate design, Boolean algebra, number systems, arithmetic, storage elements. Datapath, memory organization, instruction set architecture, assembly language. Credit not allowed for both ECE 2020 and ECE 2030.

ECE 2025. Introduction to Signal Processing. 4 Credit Hours.

Introduction to signal processing for discrete-time and continuous-time signals. Filtering. Frequency response. Fourier Transform. Z Transform. Laboratory emphasizes computer-based signal processing. Credit not allowed for both ECE 2025 and ECE 2026.

ECE 2026. Introduction to Signal Processing. 3 Credit Hours.

Introduction to discrete-time signal processing and linear systems. Sampling theorem, filtering, frequency response, Discrete Fourier Transform, Z-Transform. Laboratory emphasizes computer-based signal processing. Credit not allowed for both ECE 2026 and ECE 2025.

ECE 2030. Introduction to Computer Engineering. 3 Credit Hours.

Computer system and digital design principles. Architectural concepts, software, Boolean algebra, number systems, combinational datapath elements, sequential logic, and storage elements. Design of DRAM control and I/O bus. Credit not allowed for both ECE 2030 and ECE 2020.

ECE 2031. Digital Design Laboratory. 2 Credit Hours.

Design and implementation of digital systems, including a team design project. CAD tools, project design methodologies, logic synthesis, and assembly language programming.

ECE 2035. Programming for Hardware/Software Systems. 4 Credit Hours.

Creation of complex execution and storage mechanisms, based on instruction set architecture, for software design including high-level programming languages and operating systems. Programming design projects. Credit not allowed for both ECE 2035 and ECE 3035.

ECE 2036. Engineering Software Design. 4 Credit Hours.

Object-oriented software methods for engineering applications. Numerical analysis methods; simulations and graphical presentation of simulation results; analysis of numerical precision. Programming projects. Credit not allowed for both ECE 2036 and ECE 3090.

ECE 2040. Circuit Analysis. 3 Credit Hours.

Basic concepts of DC and AC circuit theory and analysis.

ECE 2045. Practical Skills and Design. 1 Credit Hour.

This course teaches practical skills, such as soldering and prototyping, and introduces students to ECE design.

ECE 20X2. Transfer-Digital Des Lab. 2 Credit Hours.**ECE 20X3. Transfer-Digital Systems. 3 Credit Hours.****ECE 2698. Undergraduate Research Assistantship. 1-12 Credit Hours.**

Independent research conducted under the guidance of a faculty member.

ECE 2699. Undergraduate Research. 1-12 Credit Hours.

Independent Research conducted under the guidance of a faculty member.

ECE 2801. Special Topics. 1 Credit Hour.**ECE 2802. Special Topics. 2 Credit Hours.****ECE 2803. Special Topics. 3 Credit Hours.****ECE 2804. Special Topics. 4 Credit Hours.****ECE 2805. Special Topics. 5 Credit Hours.****ECE 2811. Special Topics. 1 Credit Hour.****ECE 2812. Special Topics. 2 Credit Hours.****ECE 2813. Special Topics. 3 Credit Hours.****ECE 2814. Special Topics. 4 Credit Hours.****ECE 2815. Special Topics. 5 Credit Hours.****ECE 2871. Special Topics. 1 Credit Hour.****ECE 2881. Special Topics. 1 Credit Hour.****ECE 2882. Special Topics. 2 Credit Hours.****ECE 2883. Special Topics. 3 Credit Hours.****ECE 2884. Special Topics. 4 Credit Hours.****ECE 2891. Special Topics. 1 Credit Hour.****ECE 2892. Special Topics. 2 Credit Hours.****ECE 2893. Special Topics. 3 Credit Hours.****ECE 2894. Special Topics. 4 Credit Hours.****ECE 2900. Special Problems. 1-21 Credit Hours.****ECE 2901. Special Problems. 1-21 Credit Hours.****ECE 2902. Special Problems. 1-21 Credit Hours.****ECE 2903. Special Problems. 1-21 Credit Hours.****ECE 2XXX. Electrical and Computer Engineering Elective. 1-21 Credit Hours.****ECE 3005. Professional and Technical Communications for ECE. 1 Credit Hour.**

Written, oral, and visual communication skills required by electrical and computer engineers. Prepares students for advanced communication tasks required in academic and professional settings.

ECE 3006. Co-Curricular Professional Communications for ECE. 0 Credit Hours.

This course documents student completion of ECE professional communications requirement through workshops, seminars, research projects, co/extra-curricular activities, etc.

ECE 3011. ECE Design Fundamentals. 2 Credit Hours.

This course teaches system-level design, including both software and hardware. Through activities and projects, students gain exposure to entrepreneurship, product lifecycle management, prototyping, and testing.

ECE 3020. Mathematical Foundations of Computer Engineering. 3 Credit Hours.

Fundamental concepts in discrete mathematics and their efficient realization via algorithms, data structures, computer programs, and hardware. Discussion of engineering and computational applications.

ECE 3025. Electromagnetics. 3 Credit Hours.

To present the laws and applications of electromagnetics.

ECE 3030. Physical Foundations of Computer Engineering. 3 Credit Hours.

Basic principles governing the physical realization of computing systems and their relationship to characteristics such as performance, energy, and robustness. Implementation technologies.

ECE 3035. Mechanisms for Computing Systems. 4 Credit Hours.

Computing system execution and storage mechanisms, starting with instruction set architecture and concluding with support for high level languages and operating systems. Credit not allowed for both ECE 3035 and ECE 2035.

ECE 3040. Microelectronic Circuits. 4 Credit Hours.

Basic concepts of microelectronic materials, devices, and circuits.

ECE 3043. Measurements, Circuits, and Microelectronics Laboratory. 2 Credit Hours.

Basic electronic test instrumentation. Elementary passive and active circuits using both discrete (diodes, bipolar junction transistors, MOSFETs) and integrated devices (operational amplifiers). Credit not allowed for both ECE 3043 and ECE 3041.

ECE 3050. Analog Electronics. 3 Credit Hours.

To present concepts of analysis and design of electronic circuits and systems. Biasing, small-signal analysis, frequency response, feedback amplifiers, active filters, non-linear op-amp applications, and oscillators.

ECE 3055. Computer Architecture and Operating Systems. 4 Credit Hours.

Core concepts of computer architecture and operating systems. Instruction set architectures (ISA), compiler/ISA relationships, pipelined datapaths. Memory hierarchy, memory management, and protection. Processes, threads, CPU scheduling, and associated techniques. Credit not allowed for both ECE 3055 and ECE 3056.

ECE 3057. Architecture, Systems, Concurrency and Energy in Computation. 3 Credit Hours.

Basic organizational principles of the major components of a processor - the core, memory hierarchy, I/O subsystem and basic operating system constructs that utilize them.

ECE 3058. Architecture, Systems, Concurrency, and Energy in Computation. 4 Credit Hours.

Basic organizational principles of the major components of a processor – the core, memory hierarchy, I/O subsystem and basic operating system constructs that utilize them.

ECE 3060. VLSI and Advanced Digital Design. 4 Credit Hours.

Advanced digital design issues in the context of VLSI systems. Introduction to a design methodology that encompasses the range from behavioral models to circuit simulation. Credit will not be awarded for ECE 3060 and ECE 3150.

ECE 3065. Electromagnetic Applications. 3 Credit Hours.

To present concepts in waveguiding and radiation, with application to microwaves, antennas, and optics. Credit will not be awarded for ECE 3065 and ECE 4350.

ECE 3070. Electromechanical and Electromagnetic Energy Conversion. 3 Credit Hours.

This course serves as an introduction to three-phase power systems, electromechanical energy conversion, and operating principles of electric machines.

ECE 3071. Modern Electric Energy Systems. 3 Credit Hours.

Non-renewable and renewable/sustainable energy sources. Processes, costs, and environmental impact of conversion into electric energy. Delivery and control of electric energy, electromechanical systems. Credit not allowed for both ECE 3071 and ECE 3072.

ECE 3072. Electrical Energy Systems. 3 Credit Hours.

Non-renewable and renewable/sustainable energy sources. Processes, costs, and environmental impact of conversion into electric energy. Delivery and control of electric energy, electromechanical systems. Credit not allowed for both ECE 3072 and ECE 3071.

ECE 3075. Random Signals. 3 Credit Hours.

Study of random variables and random processes for applications in electrical and computer engineering. Includes an introduction to statistical filtering, parameter estimation, Markov processes.

ECE 3076. Computer Communications. 3 Credit Hours.

Presents the basic concepts of computer communications network protocols.

ECE 3077. Introduction to Probability and Statistics for ECE. 3 Credit Hours.

Introduction to probability, random variables, distributions, estimation, confidence intervals, linear regression and other tools for describing and managing uncertainty in electrical and computer engineering.

ECE 3080. Semiconductor Devices for Computer Engineering and Telecommunication Systems. 3 Credit Hours.

To gain an understanding of the device needs for current and future computers, and fiber optic and wireless communication systems addressing the future needs of high-frequency, GHz-range, device operation.

ECE 3084. Signals and Systems. 3 Credit Hours.

Continuous-time linear systems and signals, their mathematical representations, and computational tools. Fourier and Laplace transforms, convolutions, input-output responses, stability.

ECE 3085. Introduction to Systems and Controls. 3 Credit Hours.

Theory of linear time-invariant systems for continuous and discrete time. Laplace and Z-Transforms. Transfer function and state space representations. Introduction to feedback control theory.

ECE 3150. VLSI and Advanced Digital Design. 4 Credit Hours.

Advanced digital design issues in the context of VLSI systems. Introduction to a design methodology that encompasses the range from architectural models to circuit simulation. Credit not awarded for ECE 3150 and ECE 3060.

ECE 3170. Cryptographic Hardware for Embedded Systems. 4 Credit Hours.

Introduction to cryptography and authentication from a hardware-centric perspective. Historic ciphers, symmetric and asymmetric encryption, and power analysis attacks are taught from a digital and VLSI design perspective.

ECE 3251. Optimization for Information Systems. 3 Credit Hours.

An introduction to the fundamentals of optimization with a focus on algorithms and applications in signal processing, control systems, machine learning, and robotics.

ECE 3300. Electromechanical and Electromagnetic Energy Conversion. 3 Credit Hours.

Introduction to three phase power systems, electromechanical energy conversion and operating principles of electric machines.

ECE 3400. Analog Electronics. 3 Credit Hours.

Analysis and design of electronic circuits and systems. Biasing, small-signal analysis, frequency response, feedback amplifiers, active filters, non-linear op-amp applications, and oscillators.

ECE 3450. Semiconductor Devices. 3 Credit Hours.

Properties of semiconductor devices. Applications in current and future computers, fiber optic and wireless communication systems. Future needs of high frequency, GHz-range, device operation.

ECE 3550. Feedback Control Systems. 3 Credit Hours.

Analysis and design of control systems. Laplace transforms, transfer functions, and stability. Feedback systems: tracking and disturbance rejection. Graphical design techniques.

ECE 3600. Computer Communications. 3 Credit Hours.

Basic concepts of computer communication network protocols.

ECE 3710. Circuits and Electronics. 2 Credit Hours.

An introduction to electric circuit elements and electronic devices and a study of circuits containing such devices.

ECE 3741. Instrumentation and Electronics Lab. 1 Credit Hour.

Basic analog and digital electronic circuits and principles. Techniques of electrical and electronic measurements with laboratory instruments.

ECE 3801. Special Topics. 1 Credit Hour.**ECE 3802. Special Topics. 2 Credit Hours.****ECE 3803. Special Topics. 3 Credit Hours.****ECE 3804. Special Topics. 4 Credit Hours.****ECE 3805. Special Topics. 5 Credit Hours.****ECE 3811. Special Topics. 1 Credit Hour.****ECE 3812. Special Topics. 2 Credit Hours.****ECE 3813. Special Topics. 3 Credit Hours.****ECE 3814. Special Topics. 4 Credit Hours.****ECE 3815. Special Topics. 5 Credit Hours.****ECE 3872. Special Topics. 2 Credit Hours.****ECE 3881. Special Topics. 1 Credit Hour.****ECE 3882. Special Topics. 2 Credit Hours.****ECE 3883. Special Topics. 3 Credit Hours.****ECE 3884. Special Topics. 4 Credit Hours.****ECE 3891. Special Topics. 1 Credit Hour.****ECE 3892. Special Topics. 2 Credit Hours.****ECE 3893. Special Topics. 3 Credit Hours.****ECE 3894. Special Topics. 4 Credit Hours.****ECE 3900. Special Problems. 1-21 Credit Hours.****ECE 3901. Special Problems. 1-21 Credit Hours.****ECE 3902. Special Problems. 1-21 Credit Hours.****ECE 3903. Special Problems. 1-21 Credit Hours.****ECE 3951. Undergraduate Research I. 1-21 Credit Hours.**

Participation in an individual or group research project under the direction of a faculty member.

ECE 3952. Undergraduate Research II. 1-21 Credit Hours.

Participation in an individual or group research project under the direction of a faculty member. Requires a formal research report.

ECE 3XXX. Electrical and Computer Engineering Elective. 1-21 Credit Hours.**ECE 4001. Engineering Practice and Professionalism. 2 Credit Hours.**

Technical tools and professional issues for engineering practice and early career development. Engineering ethics, design tools, financial and economic principles, project management, probabilistic and statistical techniques, and decision making. Credit not allowed for both ECE 4001 and ECE 4000.

ECE 4007. ECE Culminating Design Project. 4 Credit Hours.

Team-oriented culminating design project in electrical/ computer engineering, incorporating engineering standards and realistic constraints. Requires formal reports and group presentations. Credit not allowed for both ECE 4007 and ECE 4006.

ECE 4011. ECE Culminating Design Project I. 2 Credit Hours.

First semester of ECE culminating design sequence. Design tools, financial principles, project management, probabilistic and statistical techniques, team forming. Requires formal reports and group presentations.

ECE 4012. ECE Culminating Design Project II. 3 Credit Hours.

Second semester of ECE culminating design sequence. Team project in ECE incorporating engineering standards and realistic constraints. Requires formal reports and group presentations.

ECE 4013. ECE Culminating Design I. 1 Credit Hour.

First course in a culminating design sequence. Student teams design, build, test, document, demonstrate prototype system reflective of knowledge gained as an undergraduate engineering student.

ECE 4014. ECE Culminating Design 2. 2 Credit Hours.

Second course in a culminating design sequence. Student teams design, build, test, document, demonstrate prototype system reflective of knowledge gained as an undergraduate engineering student.

ECE 4015. ECE-Only Single-Semester Capstone Design. 3 Credit Hours.

A single-semester ECE culminating design experience forming ECE-only teams, proposing, prototyping, testing, demonstrating, formally presenting and documenting projects incorporating engineering standards and realistic constraints.

ECE 4043. Senior Analog Electronics Laboratory. 2 Credit Hours.

Experiments in analog electronics using discrete devices and off-the-shelf integrated circuits.

ECE 4053. Research Methods. 2 Credit Hours.

Course provides methods and practices for literature searching, reference management, and summary preparation. Coverage includes journals, conferences, theses, patents, grants, roadmaps, and companies.

ECE 4100. Advanced Computer Architecture. 3 Credit Hours.

Comprehensive coverage of the architecture and system issues that confront the design of high-performance workstation/PC computer architectures with emphasis on quantitative evaluation. Credit is not allowed for both ECE 4100 and any of the following courses: ECE 6100, CS 4290, CS 6290.

ECE 4110. Internetwork Programming. 4 Credit Hours.

Exploration of Internet implementation as a network of computing systems. Internetworking skills for design and implementation of hardware and software Internet products.

ECE 4112. Internetwork Security. 3 Credit Hours.

Hands-on experimentation and evaluation of internet security theory, principles, and practices. Laboratory component involves implementing both defensive and offensive security techniques. Credit not awarded for both ECE 4112 and ECE 4115.

ECE 4115. Introduction to Computer Security. 4 Credit Hours.

Introductory topics in computer security are presented with an emphasis on fundamental security primitives and current security challenges facing society. Credit not awarded for both ECE 4115 and ECE 4112.

ECE 4117. Introduction to Malware Reverse Engineering. 4 Credit Hours.

This course exposes students to an immersive, hands-on experience in the dissection and analysis of the code, structure, and functionality of malicious software.

ECE 4122. Advanced Programming Techniques for Engineering Applications. 3 Credit Hours.

Course covers a number of programming techniques for distributed and parallel computing and other advanced methods, such as multiprecision arithmetic and nonblocking I/O. Credit not awarded for ECE 4122 and ECE 6122.

ECE 4130. Advanced VLSI Systems. 4 Credit Hours.

An advanced treatment of VLSI systems analysis, design, and testing with emphasis on complex systems and how they are incorporated into a silicon environment. Credit is not allowed for both ECE 4130 and ECE 6130.

ECE 4147. Adv Malware Analysis. 3 Credit Hours.

This course covers advanced approaches for the analysis of malicious software and explores recent research and unsolved problems in software protection and forensics.

ECE 4150. Cloud Computing. 3 Credit Hours.

Cloud computing technologies, computation models, and applications, design methodologies for cloud applications, use of cloud-based languages and tools in developing advanced applications.

ECE 4156. Hardware-Oriented Security and Trust. 3 Credit Hours.

Fundamental concepts, foundation, and methodologies for the design of trustworthy circuits including protection of the hardware platform against tampering. Physical cloning of cryptographic VLSI circuits.

ECE 4180. Embedded Systems Design. 4 Credit Hours.

Processors, chipsets, busses, and I/O devices for high-ended embedded systems. Embedded operating systems; device drivers and applications for embedded systems.

ECE 4181. Embedded Computing Systems. 4 Credit Hours.

Algorithms and methodologies for the design of real-time, low-power embedded computing systems.

ECE 4252. Fundamentals of Machine Learning (FunML). 3 Credit Hours.

An introduction to the fundamentals and applications of Machine Learning. Students cannot receive credit for both ECE 4252 and CS 4641.

ECE 4258. Digital Image Processing. 3 Credit Hours.

An introduction to the Fundamentals of Image Processing.

ECE 4260. Random Signals and Applications. 3 Credit Hours.

Introduction to random signals and processes with emphasis on applications in ECE. Includes basic estimation theory, linear prediction, and statistical modeling.

ECE 4270. Fundamentals of Digital Signal Processing. 3 Credit Hours.

Introduction to digital signal processing. Sampling theorem, discrete-time Fourier transform. Power spectrum, discrete Fourier transform and the FFT algorithm, Z-transform, digital filter design and implementation.

ECE 4271. Applications of Digital Signal Processing. 4 Credit Hours.

Applications of DSP in speech, image processing, radar, pattern recognition, and adaptive filtering requiring working software implementations applied to the analysis of real signals.

ECE 4273. Design Synthesis of Application-specific Signal Processors. 3 Credit Hours.

Fundamentals of theory and practice of DSP chip design in VHDL. Exposure to tools and environments for chip design, simulation, and verification.

ECE 4320. Power System Analysis and Control. 3 Credit Hours.

Introduces basic concepts in electric power generation, distribution, system control, and economic operation.

ECE 4321. Power System Engineering. 3 Credit Hours.

To introduce basic concepts of electric power system design, encompassing protection, stability, and control.

ECE 4325. Electric Power Quality. 3 Credit Hours.

Transients and harmonics in power systems, analysis methods and mitigation practices. Causes of power quality problems and relationship to equipment susceptibility. Credit not allowed for both ECE 4325 and ECE 6340.

ECE 4330. Power Electronics. 3 Credit Hours.

Introduces power semiconductor devices and power electronic converters, including single-phase and three-phase ac/dc rectifiers, ac voltage controllers, dc/dc converters, and dc/ac inverters.

ECE 4335. Electric Machinery Analysis. 3 Credit Hours.

Advanced theory of AC machines, including AC motor winding design, finite element analysis, induction motor design, permanent magnet machine design, and synchronous machine dynamics. Credit is not allowed for both ECE 4335 and ECE 6335.

ECE 4350. Electromagnetic and Microwave Applications. 3 Credit Hours.

Presents concepts of electromagnetic fields applied to microwave circuit design and antenna radiation. Credit will not be awarded for ECE 4350 and ECE 3065.

ECE 4360. RF-Microwave Measurement Laboratory. 2 Credit Hours.

RF/microwave measurement theory and techniques. Use of state-of-the-art equipment operating into the GHz range.

ECE 4370. Antenna Engineering. 3 Credit Hours.

Basic theory, application, and design of a broad range of antennas.

ECE 4371. Antenna Engineering Laboratory. 1 Credit Hour.

Experimentation to develop a practical understanding of antennas and their properties.

ECE 4390. Introduction to Radar and Electromagnetic Sensing. 3 Credit Hours.

Introduces students to radar systems, including pulsed, CW, CWFM, and MTI radars. Other techniques for electromagnetic sensing such as radiometry and EM tagging are discussed.

ECE 4391. Electromagnetic Compatibility. 3 Credit Hours.

To study electromagnetic interference and susceptibility of electrical systems, with application to analog and digital circuits.

ECE 4415. RF Engineering I. 3 Credit Hours.

Fundamentals of RF engineering. Components at high frequencies, device modeling, amplifiers, lumped-element and microstrip impedance transformation networks, S-parameter-based design of RF and microwave amplifiers.

ECE 4418. RF Engineering II. 3 Credit Hours.

Fundamentals learned in RF-I are employed to design the elements of radio receivers, transmitters, and similar systems. Systems analysis, mixers, detectors, power amplifiers, low-noise amplifiers, and oscillators are covered.

ECE 4420. Digital Integrated Circuits. 3 Credit Hours.

Analysis and design of bipolar and MOS digital integrated circuit families and their applications in modern electronic systems.

ECE 4430. Analog Integrated Circuits. 3 Credit Hours.

Analysis and design of analog ICs using analytic techniques and CAD tools. Topics include amplifiers, current sources, output circuits, and other analog building blocks.

ECE 4435. Operational Amplifier Design. 3 Credit Hours.

Analysis and design techniques for utilization of integrated circuit operational amplifiers for applications in electronic systems.

ECE 4445. Audio Engineering. 3 Credit Hours.

Concepts of acoustics and electroacoustic modeling for the analysis and design of microphones, loudspeakers, and crossover networks. Methods of analysis and design of audio power amplifiers.

ECE 4446. Audio Engineering Laboratory. 1 Credit Hour.

A companion laboratory to ECE 4445. Design, analysis, construction, modeling, and testing of circuits and systems pertaining to audio engineering.

ECE 4448. Guitar Amplification and Effects. 3 Credit Hours.

Mathematical analysis and laboratory measurement of vibrating strings, electromagnetic pickups, vacuum tube amplifiers, solid-state distortion, and swept filter effects.

ECE 4450. Analog Circuits for Music Synthesis. 3 Credit Hours.

Circuits from classic analog synthesizers: nonlinear waveshapers and voltage-controlled oscillators, filters, and amplifier using operational transconductance amplifiers and the dynamic resistance of semiconductors.

ECE 4452. IC Fabrication. 3 Credit Hours.

Introduction to microelectronic processing technologies and CMOS. Includes a laboratory for fabrication/testing of MOS transistors, basic CMOS circuits, integrated resistors and capacitors. Credit will not be awarded for ECE 4452 and ECE 4752.

ECE 4460. Introduction to Electronic Systems Packaging. 3 Credit Hours.

Introduction to packaging technologies, technology drivers, electrical performance, thermal management, materials, optoelectronics, RF integration, reliability, system issues, assembly, testing.

ECE 4470. Devices for Renewable Energy. 3 Credit Hours.

Students study the engineering compromises, operational physics and environmental impact of a variety of devices from solar cells, batteries, thermoelectric devices and wind generators.

ECE 4500. Optical Engineering. 3 Credit Hours.

Introduction to applications of geometric, physical optics to engineering, including optical measurements, matrix methods, instruments, interference, holography, beam optics, Fourier optics, and diffraction.

ECE 4502. Optical Fiber Communications. 4 Credit Hours.

Combined lecture-laboratory exploration of the technology of fiber optics, with emphasis on optical fiber communication systems. Credit will not be awarded for ECE 4502 and ECE 4501.

ECE 4550. Control System Design. 4 Credit Hours.

Design of control algorithms using state-space methods, microcontroller implementation of control algorithms, and laboratory projects emphasizing motion control applications.

ECE 4560. Introduction to Automation and Robotics. 4 Credit Hours.

Concurrent engineering principles; robotic manipulator kinematics, dynamics, and control; applications of robots in industry, medicine, and other areas; team projects and hands-on laboratory experience.

ECE 4570. System Theory for Communication and Control. 4 Credit Hours.

Study of the basic concepts in linear system theory and numerical linear algebra with applications to communication, computation, control, and signal processing. A unified treatment.

ECE 4575. Numerical Methods for Optimization and Optimal Control. 3 Credit Hours.

Algorithms for numerical optimization and optimal control, Gradient-descent techniques, linear programming, numerical linear system solvers, second-order methods of optimizing performance of dynamical systems.

ECE 4580. Computational Computer Vision. 3 Credit Hours.

Computational and theoretical aspects of computer vision. Application areas include robotics, autonomous vehicles, tracking, and image-guided surgery. Includes major project.

ECE 4601. Communication Systems. 3 Credit Hours.

To present the fundamentals of modern digital communication systems and evaluate their performance with realistic channel models.

ECE 4605. Topics in Networks. 4 Credit Hours.

Reviews on networking fundamentals. Latest networking technologies in wireless and wireline networks. Machine learning and data science in networks or other emerging topics. Projects included.

ECE 4606. Wireless Communications. 3 Credit Hours.

Cellular concept, wireless propagation modeling; types of digital modulation used in wireless systems, diversity combining, performance over fading channels, and multiple access techniques.

ECE 4607. Mobile and Wireless Networks. 3 Credit Hours.

Basics of mobile and wireless networking. Architectures and communication protocols for wireless sensor networks, wireless local area networks, ad-hoc networks, cellular systems, WiMAX, and Wireless Mesh Networks.

ECE 4612. Telecommunications Systems Laboratory. 1 Credit Hour.

Basic digital telecommunications systems are examined in a laboratory setting using electronic modules, covering concepts such as modulation, channel coding, AWGN, eye diagrams, and BER. Credit will not be awarded for ECE 4612 and ECE 4602.

ECE 4698. Undergraduate Research Assistantship. 1-12 Credit Hours.

Independent research conducted under the guidance of a faculty member.

ECE 4699. Undergraduate Research. 1-12 Credit Hours.

Independent Research conducted under the guidance of a faculty member.

ECE 4723. Interdisciplinary Capstone Design. 3 Credit Hours.

Seniors will work in teams to apply a systematic design process to real multi-disciplinary problems. Problems selected from a broad spectrum of interest areas, including biomedical, environmental, mechanical, industrial design, electrical and thermal/fluids. Projects must be based on the knowledge and skills acquired in earlier course work, and incorporate appropriate engineering standards and multiple realistic constraints. Emphasis is placed on the design process, the technical aspects of the design, and on reducing the proposed design to practice. The course consists of faculty and guest lectures, prototyping in design studios, and a multi-disciplinary design project.

ECE 4751. Laser Theory and Applications. 3 Credit Hours.

Provides an introduction to the theory and applications of laser principles and related instrumentation. Emphasis is on the fundamental principles underlying laser action. Crosslisted with PHYS 4751.

ECE 4753. Topics in Engineering Practice. 3 Credit Hours.

Topics of current importance offered in collaboration with an approved partner of Georgia Tech's Distance Learning Program. Crosslisted with ME 4753.

ECE 4754. Electronics Packaging Assembly, Reliability, Thermal Management, and Test. 3 Credit Hours.

The course provides hands-on instruction in electronics packaging, including assembly, reliability, thermal management, and test of next-generation microsystems. Crosslisted with ME and MSE 4754.

ECE 4755. Electronic Packaging Substrate Fabrication. 3 Credit Hours.

This course provides hands-on instruction in basic packaging substrate fabrication techniques, including interconnect design and testing, dielectric deposition, via formation, and metallization. Crosslisted with CHE 4755.

ECE 4761. Industrial Controls and Manufacturing. 3 Credit Hours.

Students are introduced to industrial controls and the fundamentals of manufacturing with hands-on experience based on lab projects using industry software and hardware for communications and control. Crosslisted with PTFE 4761.

ECE 4781. Biomedical Instrumentation. 3 Credit Hours.

A study of medical instrumentation from a systems viewpoint. Pertinent physiological and electro-physiological concepts will be covered. Credit not allowed for both ECE 4781 and (CHE 4781 or CHBE 4781 or BMED 4781 or ME 4781).

ECE 4782. Biosystems Analysis. 3 Credit Hours.

Analytical methods for modeling biological systems, including white-noise protocols for characterizing nonlinear systems. Crosslisted with BMED, CHE and ME 4782.

ECE 4783. Introduction to Medical Image Processing. 3 Credit Hours.

A study of mathematical methods used in medical acquisition and processing. Concepts, algorithms, and methods associated with acquisition, processing, and display of two- and three-dimensional medical images are studied. Crosslisted with BMED 4783.

ECE 4784. Engineering Electrophysiology. 3 Credit Hours.

Basic concepts of electrophysiology from an engineering perspective. Functionality of relevant organs and systems; instrumentation tools which monitor electrophysiology function. Crosslisted with BMED 4784.

ECE 4786. Medical Imaging Systems. 3 Credit Hours.

Introduce major biomedical and clinical imaging modalities including X-ray radiography, computed tomography (CT), nuclear medicine (SPECT and PET), magnetic resonance imaging (MRI), and ultrasound.

ECE 4795. GPU Programming for Video Games. 3 Credit Hours.

3-D graphics pipelines. Physically-based rendering. Game engine architectures. GPU architectures. Graphics APIs. Vertex and pixel shader programming. Post-processing effects. Deferred rendering.

ECE 4801. Special Topics. 1 Credit Hour.**ECE 4802. Special Topics. 2 Credit Hours.****ECE 4803. Special Topics. 3 Credit Hours.****ECE 4804. Special Topics. 4 Credit Hours.****ECE 4805. Special Topics. 5 Credit Hours.****ECE 4811. Special Topics. 1 Credit Hour.****ECE 4812. Special Topics. 2 Credit Hours.****ECE 4813. Special Topics. 3 Credit Hours.****ECE 4814. Special Topics. 4 Credit Hours.****ECE 4815. Special Topics. 5 Credit Hours.****ECE 4816. Special Topics. 6 Credit Hours.****ECE 4823. Special Topics. 3 Credit Hours.****ECE 4824. Special Topics. 4 Credit Hours.**
special topics.**ECE 4833. Special Topics. 3 Credit Hours.****ECE 4853. ECE Single-Semester Create-X Capstone Design. 3 Credit Hours.**

A single-semester ECE culminating design experience in which interdisciplinary teams propose, prototype, test, demonstrate, formally present, and document projects incorporating engineering standards and realistic constraints.

ECE 4863. Special Topics. 3 Credit Hours.
Special Topics in ECE.**ECE 4871. Special Topics. 1 Credit Hour.****ECE 4872. Special Topics. 2 Credit Hours.**
Special Topics in ECE.**ECE 4873. Special Topics. 3 Credit Hours.****ECE 4881. Special Topics. 1 Credit Hour.****ECE 4882. Special Topics. 2 Credit Hours.****ECE 4883. Special Topics. 3 Credit Hours.****ECE 4884. Special Topics. 4 Credit Hours.****ECE 4891. Special Topics. 1 Credit Hour.****ECE 4892. Special Topics. 2 Credit Hours.****ECE 4893. Special Topics. 3 Credit Hours.****ECE 4894. Special Topics. 4 Credit Hours.****ECE 4900. Special Problems. 1-21 Credit Hours.****ECE 4901. Special Problems. 1-21 Credit Hours.****ECE 4902. Special Problems. 1-21 Credit Hours.****ECE 4903. Special Problems. 1-21 Credit Hours.****ECE 4951. Undergraduate Research I. 1-21 Credit Hours.**

Participation in an individual or group research project under the direction of a faculty member.

ECE 4952. Undergraduate Research II. 1-21 Credit Hours.

Participation in an individual or group research project under the direction of a faculty member.

ECE 4XXX. Electrical and Computer Engineering Elective. 1-21 Credit Hours.

ECE 6001. Technology Entrepreneurship: Teaming, Ideation, Entrepreneurship, Intreprenurship, and Leadership. 3 Credit Hours.
Principles of entrepreneurship and intrapreneurship: teaming, ideation, and leadership. Customer discovery, cognitive biases, rapid prototyping, business models, negotiation, and capital raises will be also covered.

ECE 6100. Advanced Computer Architecture. 3 Credit Hours.
Comprehensive coverage of the architecture and system issues that confront the design of high-performance workstation/PC computer architectures with emphasis on quantitative evaluation. Credit is not allowed for both ECE 6100 and any of the following courses: ECE 4100, CS 4290, CS 6290.

ECE 6102. Dependable Distributed Systems. 3 Credit Hours.
Concepts, theory, and practice of dependable distributed systems. Techniques for tolerating hardware and software faults. Security aspects such as confidentiality, availability, and integrity.

ECE 6110. CAD for Computer Communication Networks. 3 Credit Hours.
Models and algorithms for simulation-based design and evaluation of computer networks and network protocols.

ECE 6115. Interconnection Networks for High-Performance Systems. 3 Credit Hours.
Architecture, design methodology, and trade offs of interconnection networks at various scales – on-chip (for multicore CPUs and accelerators) and off-chip (for HPC and datacenters)

ECE 6122. Advanced Programming Techniques. 3 Credit Hours.
Covers a number of advanced topics in programming methods, data management, distributed computing, and advanced algorithms used in typical engineering applications. Credit will not be awarded for ECE 6122 and ECE 4122.

ECE 6130. Advanced VLSI Systems. 3 Credit Hours.
An advanced treatment of VLSI systems analysis, design, and testing with emphasis on complex systems and how they are incorporated into a silicon environment. Credit is not allowed for both ECE 4130 and ECE 6130.

ECE 6132. Computer-aided VLSI System Design. 3 Credit Hours.
Theory and practice of computer-aided VLSI digital systems design. Logic synthesis, semi-custom VLSI design, high-level synthesis, low-power systems, and hardware/software co-design. Individual and group projects.

ECE 6133. Physical Design Automation of VLSI Systems. 3 Credit Hours.
Various design automation problems in the physical design process of VLSI circuits including clustering, partitioning, floor planning, placement, routing, and compaction.

ECE 6135. Digital Systems in Nanometer Nodes. 3 Credit Hours.
An advanced treatment of design challenges, such as power, variability, and reliability associated with digital integrated circuits and systems in nanometer nodes.

ECE 6140. Digital Systems Test. 3 Credit Hours.
Course covers the science of digital systems testing, fault models, algorithms for fault simulation and test generation, design for testability and built-in self-test.

ECE 6156. Hardware-Oriented Security and Trust. 3 Credit Hours.
Fundamental concepts, foundation, and methodologies for the design of trustworthy circuits including protection of the hardware platform against tampering. Physical cloning of cryptographic VLSI circuits.

ECE 6200. Biomedical Applications of Microelectromechanical Systems. 3 Credit Hours.

MEMS processing technologies, design of fabrication process flows, and applications of the technologies to the development of biomedical micro instrumentation and detection methodologies.

ECE 6229. Introduction to Microelectromechanical Systems. 3 Credit Hours.

Introduction to Micro-Electro-Mechanical systems: Microfabrication techniques including: photolithography, etching, physical and chemical vapor deposition, electroplating, bonding and polymer processing. Application to sensors and actuators. Credit not allowed for both ECE 6229 and ME 6229 or CHBE 6229.

ECE 6250. Advanced Digital Signal Processing. 3 Credit Hours.
An introduction to advanced signal processing methods that are used in a variety of applications areas.

ECE 6254. Statistical Machine Learning. 3 Credit Hours.
An introduction to the theory of statistical learning and practical machine learning algorithms with applications in signal processing and data analysis.

ECE 6255. Digital Processing of Speech Signals. 3 Credit Hours.
The application of digital signal processing to problems in speech communication. Part of this goal requires a laboratory project.

ECE 6258. Digital Image Processing. 3 Credit Hours.
An introduction to the theory of multidimensional signal processing and digital image processing, including key applications in multimedia products and services, and telecommunications.

ECE 6260. Data Compression and Modeling. 3 Credit Hours.
Theory and algorithms of signal encoding and decoding for data compression. Applications in information systems, digital telephony, digital television, and multimedia Internet.

ECE 6270. Convex Optimization: Theory, Algorithms, and Applications. 3 Credit Hours.

This course provides an introduction to convex optimization, covering the mathematical fundamentals of convex analysis and duality theory, algorithms, and modelling of practical applications.

ECE 6271. Adaptive Filtering. 3 Credit Hours.
Basic theory of adaptive filter design and implementation. Steepest decent, LMS algorithms, nonlinear adaptive filters, and neural networks. Analysis of performance and applications.

ECE 6272. Fundamentals of Radar Signal Processing. 3 Credit Hours.
Signal modeling including radar cross section, multipath, and clutter. Properties of the ambiguity function and coded waveforms. Algorithms for Doppler processing, detection, and radar imaging.

ECE 6273. Methods of Pattern Recognition with Application to Voice. 3 Credit Hours.
Theory and application of pattern recognition with a special application section for automatic speech recognition and related signal processing.

ECE 6274. Statistical Natural Language Processing. 3 Credit Hours.
Foundations of statistical natural language processing established for text data analysis, language engineering, information extraction, and statistical inference. Applications using large text datasets are illustrated.

ECE 6276. DSP Hardware Systems Design. 3 Credit Hours.
A study of theory and practice in the design and implementation of DSP algorithms on programmable processors, multiprocessors, and ASICs.

ECE 6279. Spatial Array Processing. 3 Credit Hours.

Introduce application areas where signals are sampled over space and time. Transfer knowledge of time-based techniques to spatial processing. Develop algorithms unique to spatial processing.

ECE 6280. Cryptography & Security. 3 Credit Hours.

Algebraic and number theory approaches to cryptographic techniques, information security, secret key and public key encryption, signature schemes, hash functions, message authentication, and key distribution. Credit not allowed for both ECE 6280 and CS 6260.

ECE 6282. Radar Imaging. 3 Credit Hours.

An indepth study of digital signal processing methods for Synthetic Aperture Radar (SAR) image formation. Methods are also applicable to sonar.

ECE 6283. Harmonic Analysis for Signal Processing. 3 Credit Hours.

Explores the role of sparse representations in signal processing. Specific topics include: frame decompositions, approximation theory, inverse problems, imaging, and compressed sensing.

ECE 6320. Power Systems Control and Operation. 3 Credit Hours.

Introduction to methods used in the real-time operation and control of power systems as well as to the hardware and software technology of energy management systems (EMS). Credit will not be awarded for both ECE 6320 and ECEP 6301.

ECE 6321. Power System Stability. 3 Credit Hours.

Techniques for stability analysis of electric power systems and applications of these methods.

ECE 6322. Power System Planning and Reliability. 3 Credit Hours.

To introduce basic concepts as well as analysis and optimization techniques underlying reliability assessment of electric power systems and planning techniques. Credit will not be awarded for both ECE 6322 and ECEP 6305.

ECE 6323. Power System Protection. 3 Credit Hours.

Theory and practice of modern power system protection techniques. Credit will not be awarded for both ECE 6323 and ECEP 6351.

ECE 6331. Power Electronic Circuits. 3 Credit Hours.

The analysis, control, and design of switching power converters: rectifiers, cycloconverters, voltage-sourced and current-source inverters, dc-dc converters, pfc and resonant converts.

ECE 6335. Electric Machinery Analysis. 3 Credit Hours.

An introduction to the analysis and basic construction principles of rotating electric machines and transformers, including ac synchronous and induction machines and dc machines. Credit is now allowed for both ECE 4335 and ECE 6335.

ECE 6336. Dynamics and Control of Electric Machine Drives. 3 Credit Hours.

A study of the dynamics and control of electric machinery and variable speed machine drive systems.

ECE 6337. Electricity Markets. 3 Credit Hours.

Comprehensive introduction to markets for electrical energy, including economic theory, market design, utility models, effects of the physical grid, and grid services.

ECE 6350. Applied Electromagnetics. 3 Credit Hours.

The methodology and application of advanced electromagnetic theory.

ECE 6360. Microwave Design. 3 Credit Hours.

Applications of electromagnetic theory to microwave components and systems. Introduction to the latest characterization and design techniques including monolithic microwave integrated circuit (MMIC) technology.

ECE 6361. Microwave Design Laboratory. 3 Credit Hours.

This laboratory course will teach microwave measurement/design fundamentals for both passive and active components. Students will use both CAD tools and network analyzers.

ECE 6370. Electromagnetic Radiation and Antennas. 3 Credit Hours.

The fundamentals of electromagnetic radiation and antennas.

ECE 6374. Cyber-Physical Security in Electric Energy Systems. 3 Credit Hours.

This course provides an introduction to cyber-physical infrastructure for protection and control of electric energy systems, communication protocols, standardization and practices for cyber security.

ECE 6375. Radio Wave Propagation in the Earth and Space Environment. 3 Credit Hours.

How the Earth's atmosphere, space plasma environment, and solar space weather, vary to affect communication, navigation, space science, and remote sensing, across the electromagnetic spectrum.

ECE 6380. Introduction to Computational Electromagnetics. 3 Credit Hours.

The practical application of the finite-difference time-domain and finite element techniques to electromagnetic problems. Computer projects are required.

ECE 6390. Satellite Communications and Navigation Systems. 3 Credit Hours.

To introduce satellite communications and navigation system design including microwave transmission, satellite transponders, earth station hardware, and satellite networks. A design project is required.

ECE 6412. Analog Integrated Circuit Design. 3 Credit Hours.

Design of analog circuits using CMOS and bipolar technologies.

ECE 6414. Analog Integrated System Design. 3 Credit Hours.

Design of analog systems using CMOS and bipolar technologies. A higher level of design for analog and digital systems is presented.

ECE 6420. Wireless IC Design. 3 Credit Hours.

Wireless system specifications are translated to architectures and building blocks compatible with silicon technology. The course focuses on the analysis and design of these blocks.

ECE 6422. Interface IC Design for MEMS and Sensors. 3 Credit Hours.

Design of low-noise interface circuits for sensors and micromechanical devices (MEMS). Design of integrated microsystems.

ECE 6435. Neuromorphic Analog VLSI Circuits. 3 Credit Hours.

Large-scale analog computation for sensory and motor processing. Analog building blocks are presented, leading to VLSI systems inspired by neurobiological architectures and computational paradigms.

ECE 6444. Silicon-Based Heterostructure Devices and Circuits. 3 Credit Hours.

Theory and design of novel silicon-germanium microelectronic devices and circuits. Materials, device physics, fabrication, measurement, circuit design, and system applications.

ECE 6445. Power Integrated-Circuit Design. 3 Credit Hours.

Analysis and design of linear dc-dc regulators and switched-inductor dc-dc supplies with CMOS and BiCMOS integrated circuits (ICs).

ECE 6450. Introduction to Microelectronics Technology. 3 Credit Hours.

Presents the fundamentals of microelectronics material, device, and circuit fabrication.

ECE 6451. Introduction to the Theory of Microelectronics. 3 Credit Hours. Basis of quantum mechanics, statistical mechanics, and the behavior of solids to serve as an introduction to the modern study of semiconductors and semiconductor devices.

ECE 6453. Theory of Electronic Devices. 3 Credit Hours.

Presents the fundamentals of electronic device operation.

ECE 6455. Semiconductor Process Control. 3 Credit Hours.

This course is designed to explore methods of applying statistical process control and statistical quality control to semiconductor manufacturing processes. Students will be required to complete a design project.

ECE 6456. Solar Cells. 3 Credit Hours.

To provide a practical understanding of semiconductor materials and technology as it relates to design and development of efficient solar cells and photovoltaic systems.

ECE 6458. Gigascale Integration. 3 Credit Hours.

Hierarchy of physical principles that enable understanding and estimation of future opportunities to achieve multibillion transistor silicon chips using sub-0.25 micron technology.

ECE 6460. Microelectromechanical Devices. 3 Credit Hours.

Fundamental concepts for design of microelectromechanical devices (MEMS), including mechanical and thermal behavior of materials and structures, transduction principles, transducer design, and modeling.

ECE 6465. Memory Device Technologies and Applications. 3 Credit Hours.

This course covers semiconductor memory technologies SRAM, DRAM, FLASH and emerging non-volatile NVMs, including bit-cell design, peripheral circuitry, array architecture, scaling trend and in-memory computing.

ECE 6500. Fourier Techniques and Signal Analysis. 3 Credit Hours.

Introduction to the use of Fourier Methods for analysis of signals.

ECE 6501. Fourier Optics and Holography. 3 Credit Hours.

Applications of the Fourier transform and linear systems theory to the analysis of optical propagation, diffraction imaging, holography, wavefront modulation, and signal processing.

ECE 6510. Electro-Optics. 3 Credit Hours.

Study of the fundamental principles and primary applications of lasers, and of detectors of optical radiation.

ECE 6515. Nanophotonics. 3 Credit Hours.

Design of nano-structures to guide light and to develop a new set of optical devices.

ECE 6520. Integrated Optics. 3 Credit Hours.

Theory and design of integrated photonic devices.

ECE 6522. Nonlinear Optics. 3 Credit Hours.

Provides an introduction to the field of nonlinear optics, exploring the physical mechanisms, applications, and experimental techniques.

ECE 6530. Modulation, Diffractive, and Crystal Optics. 3 Credit Hours.

Provides a working knowledge of temporal and spatial optical modulation, diffractive optical devices, and crystal optics.

ECE 6540. Organic Optoelectronics. 3 Credit Hours.

Fundamental understanding of the optical and electronic properties of organic materials and devices that form the basis of the emerging technological area of printed flexible optoelectronics.

ECE 6542. Optoelectronics: Devices, Integration, Packaging, Systems. 3 Credit Hours.

Optoelectronic devices (detectors, emitters, modulators) from the practical realized and theoretical performance perspective. Explores monolithic and hybrid integration of devices, packaging, and system implementation.

ECE 6543. Fiber-optic Networks. 3 Credit Hours.

Architectural, performance and design aspects of fiber-optic communications networks, components, and technologies. Relationship between the physical network implementation and the higher-level network architecture.

ECE 6550. Linear Systems and Controls. 3 Credit Hours.

Introduction to linear system theory and feedback control. Topics include state space representations, controllability and observability, linear feedback control. Credit will not be awarded for both ECE 6550 and AE 6530.

ECE 6551. Digital Control. 3 Credit Hours.

Techniques for analysis and synthesis of digital control systems. Sample-data systems, state-space systems and linear feedback design.

ECE 6552. Nonlinear Systems and Control. 3 Credit Hours.

Classical analysis techniques and stability theory for nonlinear systems. Control design for nonlinear systems, including robotic systems. Design projects.

ECE 6553. Optimal Control and Optimization. 3 Credit Hours.

Optimal control of dynamic systems, numerical optimization, techniques and their applications in solving optical-trajectory problems.

ECE 6554. Adaptive Control. 3 Credit Hours.

Methods of parameter estimation and adaptive control for systems with constant or slowly varying unknown parameters. MATLAB design projects emphasizing applications to physical systems.

ECE 6555. Optimal Estimation. 3 Credit Hours.

Techniques for signal and state estimation in the presence of measurement and process noise with the emphasis on Wiener and Kalman filtering.

ECE 6558. Stochastic Systems. 3 Credit Hours.

Advanced techniques in stochastic analysis with emphasis on stochastic dynamics, nonlinear filtering and detection, stochastic control, and stochastic optimization and simulation methods.

ECE 6559. Advanced Linear Systems. 3 Credit Hours.

Study of multivariable linear system theory and robust control design methodologies.

ECE 6560. Partial Differential Equations in Image Processing and Computer Vision. 3 Credit Hours.

Mathematical foundations and numerical aspects of partial-differential equation techniques used in computer vision. Topics include image smoothing and enhancement, edge detection, morphology, and image reconstruction.

ECE 6562. Autonomous Control of Robotic Systems. 3 Credit Hours.

Fundamental issues associated with autonomous robot control. Emphasizes biological perspective that forms the basis of many current developments in robotics.

ECE 6563. Networked Control and Multiagent Systems. 3 Credit Hours.

Covers tools and techniques for networked control systems as well as application domains and promising research directions.

ECE 6564. Nonlinear Dynamics and Chaos. 3 Credit Hours.

Introduction to the nonlinear dynamics of continuous-time and discrete-time systems. Routes to chaos. Quantification of chaos. Nonlinear time series analysis. Applications of Chaos Theory.

ECE 6601. Random Processes. 3 Credit Hours.

To develop the theoretical framework for the processing of random signals and data.

ECE 6602. Digital Communications. 3 Credit Hours.

Basic M-ary digital communications systems, with emphasis on system design and performance analysis in the presence of additive noise.

ECE 6603. Advanced Digital Communications. 3 Credit Hours.

The theory and practice of efficient digital communications over dispersive channels, including adaptive equalization and synchronization.

ECE 6604. Personal and Mobile Communications. 3 Credit Hours.

To introduce various topics that are fundamental to cellular mobile telephone systems.

ECE 6605. Information Theory. 3 Credit Hours.

To introduce the mathematical theory of communications. Emphasis will be placed on Shannon's theorems and their use in the analysis and design of communication systems.

ECE 6606. Coding Theory and Applications. 3 Credit Hours.

To introduce the theory and practice of error control coding, with emphasis on linear, cyclic, convolutional, and parallel concatenated codes.

ECE 6607. Computer Communication Networks. 3 Credit Hours.

Fundamental concepts of computer network architecture and protocols.

ECE 6610. Wireless Networks. 3 Credit Hours.

Fundamental concepts of wireless networks.

ECE 6612. Computer Network Security. 3 Credit Hours.

Fundamental concepts of network information security, including encryption, secure access methods, and vulnerabilities in network protocols, operating systems, and network applications.

ECE 6613. Broadband Access Networks. 3 Credit Hours.

To develop architectures and technologies of wireless and wired broadband access networks including 5G wireless, fiber to the home, hybrid fiber-coax, and digital subscriber line.

ECE 6615. Sensor Networks. 3 Credit Hours.

Basics of sensor network communications. Applications, architectures, and communication protocols for sensor networks are treated in depth.

ECE 6710. Ethics of Biotechnology and Bioengineering Research. 3 Credit Hours.

This course examines the ethics of biotechnological research, including issues in the realm of research ethics, bioethics, and healthcare robotics.

ECE 6727. Cyber Security Practicum. 5 Credit Hours.

Capstone independent study project placing each student in a commercial, academic or government setting where he or she identifies a major cyber security problem, and explores and evaluates a solution that addresses it with realistic assumptions about the organizational context. The chosen problem must be approved by course instructor. Cross-listed with PUBP and CS 6727.

ECE 6730. Modeling and Simulation: Foundations and Implementation. 3 Credit Hours.

Foundations and algorithms concerning the development of conceptual models for systems, and their realization in the form of computer software; discrete and continuous models. Crosslisted with CSE 6730.

ECE 6744. Topics in Engineering Practice. 3 Credit Hours.

Topics of current importance offered in collaboration with an approved partner of Georgia Tech's Distance Learning Program. Crosslisted with ME 6744.

ECE 6747. Advanced Topics in Malware Analysis. 3 Credit Hours.

This course covers advanced approaches for the analysis of malicious software and explores recent research and unsolved problems in software protection and forensics.

ECE 6770. Introduction to Cyber-Physical Systems Security. 3 Credit Hours.

This course provides an introduction to security issues relating to various cyber-physical systems including industrial control systems and those considered critical infrastructure systems.

ECE 6771. Optoelectronics: Materials, Processes, Devices. 3 Credit Hours.

Optoelectronic materials, physical processes, and devices. Includes compound semiconductor materials, excitation, recombination, gain, and modulation processes and devices such as emitters, detectors, and modulators. Crosslisted with PHYS 6771.

ECE 6776. Integrated Low-Cost Microelectronics Systems Packaging. 3 Credit Hours.

Introduction to cross-disciplinary microelectronic packaging technologies, including electrical design, thermal considerations and technologies, reliability, optoelectronic packaging, and RF/mm-packaging. Crosslisted with ME and MSE 6776.

ECE 6779. Thermal Engineering for Packaging of Micro and Nano Systems. 3 Credit Hours.

Passive, active, and hybrid thermal management techniques, and computational modeling of micro systems. Air cooling, single phase and phase change liquid cooling, heat pipes, and thermoelectrics. Crosslisted with ME 6779.

ECE 6780. Medical Image Processing. 3 Credit Hours.

Studying biomedical image analysis techniques including image enhancement, analysis, classification, and interpretation for medical decision making through practicals and projects. Cross-listed with BMED 6780.

ECE 6781. Biomedical Sensing Systems. 3 Credit Hours.

A study of physiological sensing topics from a systems viewpoint. Pertinent physiological and electro-physiological concepts will be covered. No prior knowledge of physiology or biology is needed.

ECE 6786. Medical Imaging Systems. 3 Credit Hours.

A study of the principles and design of medical imaging systems such as X-ray, ultrasound, nuclear medicine, and nuclear magnetic resonance. Crosslisted with BMED 6786.

ECE 6790. Information Processing Models in Neural Systems. 3 Credit Hours.

Examines "top-down" modeling approaches for sensorineural systems, where optimal computational principles used in engineering (e.g., information theory, Bayesian inference, control theory) explain observed information processing.

ECE 6792. Manufacturing Seminar. 1 Credit Hour.

Guest speakers on a broad range of manufacturing-related topics: research, applications, and technology. Required for Certificate in Manufacturing. Crosslisted with ISYE and ME 6792.

ECE 6XXX. Electrical and Computer Engineering Elective. 1-21 Credit Hours.

ECE 7000. Master's Thesis. 1-21 Credit Hours.

ECE 7055. GT-SJTU. 12 Credit Hours.

For GT-SJTU dual-MS students during terms when they are not taking other GT courses. Placeholder course.

ECE 7056. GT-TU. 12 Credit Hours.

For GT-TU double-MS students during terms when they are not taking other GT courses.

ECE 7057. GT-Shenzhen Research. 12 Credit Hours.

For GT-Shenzhen students during terms when they are in Atlanta on research internship with GT-Atlanta faculty.

ECE 7103. Advanced Memory System. 3 Credit Hours.

Covers the basic trade-offs in architecting a high performance memory hierarchy at all levels, starting from the on-chip cache to main memory and storage sub-system.

ECE 7141. Advanced Digital Systems Test. 3 Credit Hours.

Design and test techniques for high-speed digital systems operating at rates above 100 MHz with a practical emphasis via substantial projects.

ECE 7142. Fault Tolerant Computing. 3 Credit Hours.

Key concepts in fault-tolerant computing. Understanding and use of modern fault-tolerant hardware and software design practices. Case studies.

ECE 7252. Advanced Signal Processing Theory. 3 Credit Hours.

A lecture and seminar treatment of the latest developments in signal processing. Emphasis is placed on current literature and emerging research areas.

ECE 7350. Topics in Analytical Electromagnetics. 3 Credit Hours.

An in-depth treatment of several analytical techniques used in current practice for solving real-world EM wave propagation problems and their impact on wireless communications.

ECE 7380. Topics in Computational Electromagnetics. 3 Credit Hours.

Computational approaches for applications such as radar signature prediction, microwave antenna and device design, and modeling techniques for electronic packaging.

ECE 7721. Are You Thinking of Becoming An Academic?. 1 Credit Hour.

How to run a successful research program, advise students, apply and get a job in academia, navigate promotion and tenure, and other aspects of academia.

ECE 7722. Future Faculty Practicum. 3 Credit Hours.

The objective of the proposed class is to prepare students interested in applying for faculty positions for interview season and for successful start of academic career. After this class, students will have prepared material for applying for academic positions as well as developed interview talk with detailed feedback.

ECE 7741. Robotics Professional Preparation. 1 Credit Hour.

Preparation for a professional career in Robotics. Local & visiting speakers. Program introduction. Technical resume preparation. GT Robotics labs & resources.

ECE 7742. Robotics Professional Preparation 2. 1 Credit Hour.

Preparation for a professional career in Robotics. Local & visiting speakers. Selecting and applying for Internship. Developing capstone project proposal. Public speaking practice and preparation.

ECE 7743. Robotics Professional Preparation 3. 1 Credit Hour.

Preparation for a professional career in Robotics. Local & visiting speakers. Interview preparation & career search. Technical report writing and presentation.

ECE 7750. Mathematical Foundations of Machine Learning. 3 Credit Hours.

Provides the mathematical background for two of the pillars of modern data science: linear algebra and applied probability.

ECE 7751. Probabilistic Graphical Models in Machine Learning. 3 Credit Hours.

The course provides an introduction to theory and practice of graphical models in machine learning. It covers three main aspects; representation, probabilistic inference, and learning.

ECE 7785. Introduction to Robotics Research. 3 Credit Hours.

Familiarizes students with the core areas of robotics; mechanics, control, perception, AI, and autonomy. Provides an introduction to the mathematical tools required in robotics research.

ECE 7999. Preparation for Doctoral Qualifying Examination. 1-21 Credit Hours.

This course is reserved for students who are studying for the ECE Preliminary Exam.

ECE 8001. ECE Seminar. 1 Credit Hour.

Speakers with diverse backgrounds and representing many different industries, professions, and institutions describe their experiences, entrepreneurial ventures, and research challenges.

ECE 8002. ECE Seminar. 1 Credit Hour.

Speakers with diverse backgrounds and representing different industries, professions, and institutions describe their experiences, entrepreneurial ventures, and research challenges.

ECE 8010. Research Seminar. 1 Credit Hour.

Seminar presentations describing ECE-related research projects, centers, and other activities at Georgia Tech.

ECE 8022. Professional Communication Seminar. 1 Credit Hour.

Seminar presentations on oral and written technical communication skills needed by electrical and computer engineering professionals. Credit for this course may not be used toward the master's degree in ECE.

ECE 8740. Robotics Internship. 1-21 Credit Hours.

Graduate Internship at a partner company, GTRI or a GT Robotics lab.

ECE 8741. Robotics Capstone Project. 3 Credit Hours.

Teams or individuals apply the knowledge and skills acquired throughout the MS program to a faculty supervised robotics project.

ECE 8750. Robotics Research Foundation I. 3 Credit Hours.

Multidisciplinary research course supervised by two robotics faculty from different schools participating in the robotics Ph.D. program.

ECE 8751. Robotics Research Foundation II. 3 Credit Hours.

Continuation of AE 8751 (Robotics Research Foundation I).

ECE 8801. Special Topics. 1 Credit Hour.

ECE 8802. Special Topics. 2 Credit Hours.

ECE 8803. Special Topics. 3 Credit Hours.

Special Topics in ECE.

- ECE 8804. Special Topics. 4 Credit Hours.**
- ECE 8805. Special Topics. 5 Credit Hours.**
- ECE 8811. Special Topics. 1 Credit Hour.**
- ECE 8812. Special Topics. 2 Credit Hours.**
- ECE 8813. Special Topics. 3 Credit Hours.**
- ECE 8814. Special Topics. 4 Credit Hours.**
- ECE 8815. Special Topics. 5 Credit Hours.**
- ECE 8816. Special Topics. 6 Credit Hours.**
- ECE 8822. Special Topics. 2 Credit Hours.**
- ECE 8823. Special Topics. 3 Credit Hours.**
- ECE 8824. Special Topics. 4 Credit Hours.**
special topics.
- ECE 8833. Special Topics. 3 Credit Hours.**
- ECE 8843. Special Topics. 3 Credit Hours.**
- ECE 8853. Special Topics. 3 Credit Hours.**
- ECE 8863. Special Topics. 3 Credit Hours.**
- ECE 8873. Special Topics. 3 Credit Hours.**
- ECE 8881. Special Topics-Laboratory. 1 Credit Hour.**
- ECE 8882. Special Topics-Laboratory. 2 Credit Hours.**
- ECE 8883. Special Topics-Laboratory. 3 Credit Hours.**
- ECE 8884. Special Topics-Laboratory. 4 Credit Hours.**
- ECE 8891. Special Topics-Laboratory. 1 Credit Hour.**
- ECE 8892. Special Topics-Laboratory. 2 Credit Hours.**
- ECE 8893. Special Topics-Laboratory. 3 Credit Hours.**
- ECE 8894. Special Topics-Laboratory. 4 Credit Hours.**
- ECE 8900. Special Problems. 1-21 Credit Hours.**
- ECE 8901. Special Problems. 1-21 Credit Hours.**
- ECE 8902. Special Problems. 1-21 Credit Hours.**
- ECE 8903. Special Problems. 1-21 Credit Hours.**
- ECE 8997. Teaching Assistantship. 1-9 Credit Hours.**
For students holding graduate teaching assistantships.
- ECE 8998. Research Assistantship. 1-9 Credit Hours.**
For students holding graduate research assistantships.
- ECE 8999. Preparation for Doctoral Dissertation. 1-21 Credit Hours.**
This course is reserved for students who are actively seeking Ph.D. advisors and /or dissertation topics.
- ECE 9000. Doctoral Thesis. 1-21 Credit Hours.**