

Electrical Engineering, M.S.E.E.

COLLEGE OF ENGINEERING (<http://engineering.temple.edu>)

Learn more about the Master of Science in Electrical Engineering (<https://www.temple.edu/academics/degree-programs/electrical-engineering-ms-en-ece-msee>).

About the Program

The M.S.E.E. program offers students practice-oriented graduate-level education in Electrical and Computer Engineering. Concentrations include Computer Architectures and Microelectronics, Digital Signal Processing and Digital Data Communication, and Intelligent Systems and Control. Current active research projects in the department include embedded systems and system-on-chip design, intelligent interactive tutoring systems, intrusion detection, multisensor fusion, speaker identification, speech processing, and visualization and fault detection in multicasting networks. Other active areas of research include digital signal processing, heat dissipation problems in microchips, human-computer interaction, intelligent multimedia systems, robust and optimal control, and wireless data networks.

Time Limit for Degree Completion: 5 years

Campus Location: Main

Full-Time/Part-Time Status: Students complete the degree program through classes offered after 4:30 p.m. The degree program can be completed on a full- or part-time basis.

Interdisciplinary Study: The program encourages interdisciplinary research with other branches of engineering as well as with various departments in the sciences and applied mathematics. Recent collaborative work with the Department of Computer and Information Sciences includes visualization and fault detection in multicasting networks and image processing.

Areas of Specialization: For each of the three areas of specialization, research includes:

- Computer Architectures and Microelectronics — current practices of computer design and development; hardware realization and integrated circuit layout; MOS-integrated circuit design for high-speed digital computation and data communication; and software-level testing.
- Digital Signal Processing and Digital Data Communication — array signal processing; detection of faults in communication networks; detection of multidimensional signals in the presence of noise; filtering and modulation; intrusion detection, visualization, and security of multicast networks; multisensor data fusion; performance evaluation of local area and wireless networks, broadband networks, and protocols; speaker identification; and voice signal processing.
- Intelligent Systems and Control — intelligent tutoring systems, interactive multimedia, neuro-fuzzy control, and robust and optimal control.

For the M.S.E.E. program, students also choose between three tracks:

1. The Thesis Track is intended for students pursuing advanced research and includes 24 credits of didactic coursework, 3 credits of Project (ECE 9995), and 3 credits of Thesis (ECE 9996).
2. The Project Track introduces students to applied research and includes 27 credits of didactic coursework and 3 credits of Project (ECE 9995).
3. The Coursework Track provides students with an advanced engineering background for their future in the engineering profession through 30 credits of didactic coursework.

In the first term, the student and the ECE Graduate Program Director establish a graduate Plan of Study that outlines all required courses and the sequence for the student to follow. This form is used to track the student's progress as the various benchmarks in the program are completed. Once established, any revisions to the Plan of Study require approval in advance. However, if considering whether to change one's track, the student should note that:

- "Thesis" credits (ECE 9996) can only be applied toward the Thesis M.S.E.E. Track and cannot be applied to either the Project or Coursework Tracks.
- "Project" credits (ECE 9995) can be applied toward the Thesis and Project M.S.E.E. Tracks but cannot be used for the Coursework Track.

Job Prospects: Graduates with the M.S.E.E. are employed in high-tech industries and government laboratories with responsibilities for design, analysis, and applications of electrical engineering principles. Students who complete an M.S.E.E. with a thesis are prepared to enter a doctoral program.

Non-Matriculated Student Policy: Up to 9 credits of graduate Engineering coursework may be taken at Temple University on a non-matriculated basis and subsequently applied to the M.S.E.E. degree upon admission. If the applicant's undergraduate GPA was less than 3.0, a GPA of 3.25 or better is required on this non-matriculated graduate coursework to receive an admissions exception. Consequently, the Electrical and Computer Engineering (ECE) Graduate Program Director may encourage those with an undergraduate GPA less than 3.0 to take their first three graduate courses prior to making formal application to the M.S.E.E. program. (See the relevant Graduate School policies on special admission procedures for non-matriculated students: 02.23.11.03 (<http://bulletin.temple.edu/graduate/graduate-policies>) and 02.24.19 (<http://bulletin.temple.edu/graduate/graduate-policies>.)

Financing Opportunities: Three forms of financial aid are offered to graduate students:

1. Teaching Assistantship (TA): TA awards are made solely by the Department and require the awardee to work 20 hours per week in support of the Department's undergraduate programs. The TA is compensated with a 9-month stipend, a basic health-insurance plan, and 9 credits per term of tuition remission.
2. Research Assistantship (RA): Individual ECE faculty confer RA awards, using their research funds, upon students who appear well-qualified to carry out the research. Typically, this faculty member becomes the RA's Thesis advisor. The RA normally works up to 20 hours per week and is compensated with a stipend, basic health insurance, and tuition remission.
3. Fellowships: These highly competitive University-wide grants are typically awarded only to Ph.D.-program applicants. See the Engineering, Ph.D. (<http://bulletin.temple.edu/graduate/scd/engineering/engineering-phd>) program description for details.

Admission Requirements and Deadlines

Application Deadline:

Fall: March 1

Spring: November 1; August 1 international

Applications are processed on a continual basis. Late applications may be considered for admission. Ordinarily, the applicant is informed of an admissions decision within 4 to 6 weeks of receipt of all supporting application documents.

Applicants who plan to matriculate full-time are automatically considered for financial aid awards so no separate application for financial aid is required. **To ensure financial aid consideration for the intended term of study, however, applicants should submit a complete application by January 15 (Fall) and August 1 (Spring).**

Both admissions and financial aid award decisions originate in the Department of Electrical and Computer Engineering (ECE). Applicants are encouraged to contact the ECE Graduate Program Director for advice and consultation in the application process.

APPLY ONLINE to this graduate program.

Letters of Reference:

Number Required: 3

From Whom: Letters of recommendation should be obtained from college or research faculty who are familiar with the applicant's competency. If the applicant has an established career in engineering, one of the letters should be provided by the applicant's immediate supervisor. If the applicant has been out of school long enough that relevant academic reference letters appear impractical, s/he should contact the ECE Graduate Program Director to obtain a waiver of this admission requirement.

Coursework Required for Admission Consideration: Students not adequately prepared for advanced courses may be required to take a number of prerequisites. The ECE Department identifies the needed coursework on a case-by-case basis.

Bachelor's Degree in Discipline/Related Discipline: A bachelor's degree in Electrical Engineering or Computer Engineering is the preferred prerequisite degree. However, students who have earned a bachelor's degree in a related field are encouraged to apply, with the understanding that remedial preparatory courses may be a pre-condition of admission to the M.S.E.E. program.

University regulations stipulate that the applicant must have earned a 3.0 grade-point average on a 4.0 scale in her/his undergraduate studies, but admission exceptions are made for a variety of circumstances. (See Graduate School Policy 02.23.11.03 (<http://bulletin.temple.edu/graduate/graduate-policies>)). The ECE Graduate Program Director helps the applicant navigate the admission possibilities, including the "Non-Matriculated Student Policy" option.

Statement of Goals: Describe your relevant technical experiences and career goals in one to two pages.

Standardized Test Scores:

GRE: Required. Scores must be no more than 5 years in advance of the application date. (See Graduate School Policy 02.23.12 (<http://bulletin.temple.edu/graduate/graduate-policies>)). Applicants who require a waiver of the GRE should consult the ECE Graduate Program Director concerning the mechanics and consequences of obtaining an exception.

TOEFL: 79 iBT or 550 PBT minimum. (See Graduate School Policy 02.23.13.01 (<http://bulletin.temple.edu/graduate/graduate-policies>)).

Resume: Current resume required.

Transfer Credit: Graduate credits taken at an accredited institution prior to matriculation may be transferred into the M.S.E.E. program. In order to transfer, the courses must be equivalent to courses offered at Temple in the student's area of study and research, and the grades must be "B" or better. The maximum number of credits a student may transfer is 6. (See Graduate School Policy 02.24.21 (<http://bulletin.temple.edu/graduate/graduate-policies>)).

Test Waivers: Applicants with two or more years of employment in an engineering profession performing engineering design and analysis may request a waiver of the GRE. Consult with the ECE Graduate Program Director concerning the mechanics and consequences of obtaining an exception.

Program Requirements

General Program Requirements:

Number of Credits Required Beyond the Baccalaureate: 30

Required Courses:

Thesis Track

Code	Title	Credit Hours
Core Courses		
ECE 5022	Engineering Analysis and Applications	3
ECE 5033	Probability and Random Processes	3
Electives ¹		18
Non-Didactic Courses		
ECE 9995	Project	3
ECE 9996	Thesis	3
Total Credit Hours		30

¹ Coursework may include up to, but no more than, 3 credits of ENGR 9182 Independent Study I or 3 credits of ECE 9991 Directed Research. Furthermore, students who wish to take graduate coursework outside the College of Engineering in one of Temple University's other schools/colleges need to obtain the appropriate written approvals on their Plan of Study form.

Project Track

Code	Title	Credit Hours
Core Courses		
ECE 5022	Engineering Analysis and Applications	3
ECE 5033	Probability and Random Processes	3
Electives ¹		21
Non-Didactic Course		
ECE 9995	Project	3
Total Credit Hours		30

¹ Coursework may include up to, but no more than, 3 credits of ENGR 9182 Independent Study I or 3 credits of ECE 9991 Directed Research. Furthermore, students who wish to take graduate coursework outside the College of Engineering in one of Temple University's other schools/colleges need to obtain the appropriate written approvals on their Plan of Study form.

Coursework Track

Code	Title	Credit Hours
Core Courses		
ECE 5022	Engineering Analysis and Applications	3
ECE 5033	Probability and Random Processes	3
Electives ¹		24
Total Credit Hours		30

¹ Coursework may include up to, but no more than, 3 credits of ENGR 9182 Independent Study I or 3 credits of ECE 9991 Directed Research. Furthermore, students who wish to take graduate coursework outside the College of Engineering in one of Temple University's other schools/colleges need to obtain the appropriate written approvals on their Plan of Study form.

Culminating Events:

Thesis Track:

The culminating events in the Thesis Track are typically undertaken during the last two successive terms of study. Successful completion requires the following:

- **Thesis Proposal — ECE 9995 Project (3 credits)**
Under the guidance of the advisor, the student conducts independent research on an applied engineering topic of current interest and registers for ECE 9995. This work includes the research and preliminary results that form the basis of an extended study that the student plans to carry on in ECE 9996 Thesis in the following term. The student submits a research report as her/his Thesis Proposal to a committee consisting of three or more faculty members, including the faculty advisor, and presents her/his proposal in an open College-wide seminar, which is scheduled and posted at least 10 business days in advance of the presentation date. Immediately following the presentation, the student's advisory committee questions the student about the details and strategy of the proposed research. The committee then accepts, accepts with revisions, or rejects the proposal. The student must pass the Thesis Proposal before registering for ECE 9996. If the student fails Thesis Proposal, s/he may either re-register for ECE 9995 (1 credit) in the next regular term and repeat the entire proposal process or consider switching to the Project or Coursework Track. *NOTE: A second failure of Thesis Proposal results in automatic dismissal from the University.* If switching to another track, the Plan of Study form requires updating and appropriate approvals.
- **Thesis Defense — ECE 9996 Thesis (3 credits)**
The student should register for ECE 9996 in the term that s/he plans to defend the thesis. The thesis document should be prepared in a format compliant with University standards. (See Graduate School Policy 02.26.12.02 (<http://bulletin.temple.edu/graduate/graduate-policies>).) Two weeks prior to the thesis defense, the student provides the committee with a copy of the completed thesis and posts an announcement of the defense, which is to take place during a regular academic term (i.e., not scheduled during study days, final exams, or the breaks between terms). If the student is to graduate in the same term as the thesis defense is held, then the defense should take place at least 30 days prior to the end of the term.
The thesis defense is an open College seminar in which the student presents the concepts and results of her/his research. Immediately following the defense, the thesis committee convenes to closely examine the student's research and decide to accept the thesis as provided, accept the thesis with revisions, or not accept the thesis. If the thesis is accepted, a letter grade for ECE 9996 is assigned. If the thesis is accepted with revisions, then the student must submit the revised thesis within 30 days and with the approval of the Thesis Committee. If the thesis is not accepted, but the committee decides to not fail the student, an "R" grade is assigned to ECE 9996. In the following term, the student registers for one credit of ENGR 9991 Directed Research until s/he is again prepared to attempt the defense. The defense procedures described above are then carried out again in the term that the student is prepared to defend the thesis.

Project Track:

The culminating event for the Project Track is ECE 9995 Project. This entails a one-term research activity done under the supervision of a full-time faculty advisor on an applied engineering topic of interest. Near the end of the term, the student prepares a report of her/his findings and presents the study in an open departmental seminar. Both the seminar and the written report are used to determine the student's grade for ECE 9995. The grade is determined jointly by the advisor and another designated grader selected by the Graduate Program Director.

Coursework Track:

No culminating event is warranted for the Coursework Track.

Contacts

Program Web Address:

<https://www.temple.edu/academics/degree-programs/electrical-engineering-ms-en-ece-msee>

Department Information:

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215-204-7800

Submission Address for Application Materials:

<https://apply.temple.edu/Engineering/>

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Courses

ECE 5022. Engineering Analysis and Applications. 3 Credit Hours.

Vector space, basis, projection, null space, function space, L2 and space of continuous functions, Hilbert space, orthogonality, generalized Fourier series, linear transformation, adjoint transformation, eigenvalue problem, linear functional, Gateaux and Frechet differential, constrained optimization, infinite dimensional systems, complex analysis.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

ECE 5033. Probability and Random Processes. 3 Credit Hours.

Sets and events, Random variables, Distribution and density functions, Functions of multiple random variables, Moments and conditional statistics, Information entropy, stochastic processes, wide-sense stationary process, ergodicity, correlation, and power spectrum of stationary processes. Applications to sampling theory and signal modulation and detection.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

ECE 5116. Spacecraft Systems Engineering. 3 Credit Hours.

The concept of systems engineering is introduced using a satellite application. Systems engineering is a top-down approach to the design, implementation, testing, and deployment of large-scale systems to meet the needs of users. The topics will include systems engineering methodology, dynamics of spacecraft, and celestial mechanics. This course will also introduce the notion of invention and innovation, and how they are related to the intellectual property issues.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

ECE 5314. Microelectronics. 3 Credit Hours.

Advanced study of electronic devices and their applications to linear, non-linear, and digital circuits; transistors, FET's, amplifiers, digital integrated circuits, and VLSI's; Software design emphasized. A term project will be assigned.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

ECE 5324. VLSI System Design and Testing. 3 Credit Hours.

An introduction to a hierarchical design methodology of VLSI; study of basic logic elements and design methods in nMOS and CMOS; development of testable designs; the physics of MOS devices and fabrications processes; design rules and computation of circuit parameters from layout; system level design techniques; circuit structures with built-in self-test, design-for-test and self-checking features.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites:

ECE 5314|Minimum Grade of C|May not be taken concurrently.

ECE 5344. Fundamentals of Bio-MEMS and Biomedical Microdevices. 3 Credit Hours.

The course introduces the basic concepts for design and principle of bio-micro-electro-mechanical systems (BioMEMS) and biomedical micro-integrated systems. Wireless communication in context to biomedical devices are described. Microelectronics process modules used in the design and fabrication of MEMS and micro-integrated systems are presented. Applications of these systems in a variety of sensors and transducers are considered. Recent advances in biomedical applications of MEMS are discussed in detail.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

ECE 5412. Control System Analysis. 3 Credit Hours.

Review of control concepts and application; state space representation of dynamical systems; controllability, observability; time invariant and time varying systems, design of full state feedback and output feedback systems; eigenstructure assignment; the linear quadratic regulator; Kalman filter; estimation and filtering; robust control via eigenstructure design, Kharitonov theorem, application examples.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

ECE 5432. Game Theory and Applications in Engineering. 3 Credit Hours.

The course covers the basic framework for strategic games and its various manifestations. Topics include matrix games, extensive form games, mixed strategies, repeated games, Bayesian games, and cooperative games. The course continues with various applications of game theory in engineering systems. The course also covers applications of game theory as a design tool for engineering multi-agent systems, i.e., systems that are comprised of a collection of programmable decision-making components.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

ECE 5512. Intro Digital Comm. 3 Credit Hours.

Baseband pulse, digital, and passband communications systems; properties and bandwidth of signals and noise; detection of signals in noise; signal-to-noise ratio (SNR); distortionless transmission and intersymbol interference; pulse code modulation; amplitude, phase and frequency modulation and demodulation; simulation of communication systems.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

ECE 5514. Digital Signal Processing Analysis. 3 Credit Hours.

Topics covered are: various types of digital signal processing (DSP) techniques such as convolution, correlation, and filtering, as well as Finite Impulse Response (FIR) and Infinite Impulse Response (IIR) all pass and comb digital filters, the Discrete Fourier Transform, and the use of MATLAB as a tool for DSP software tasks. A term project will be assigned.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

ECE 5516. Introduction to Communication Networks. 3 Credit Hours.

Introduction to Internet and TCP and IP protocols, telephone networks, Local Area Networks, packet switching, ATM, and other related topics.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

ECE 5526. Engineering Principles of Computer Intrusion and Detection. 3 Credit Hours.

This course provides an introduction of computer intrusion and detection techniques. It gives theoretical and practical foundations necessary to continue further learning of computer security. We will study and analyze critical security vulnerabilities of software design and network and information systems. The learned skills are widely used by IT security analysts in industries. At the end of the class the students will be able to understand basic concepts of intrusion detection and traffic analysis from a practical point of view. This course will provide the tools and knowledge necessary to continue further learning in computer security and advance further in the profession.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites:

ECE 5516|Minimum Grade of B-|May not be taken concurrently.

ECE 5528. Introduction to Cryptography and Information Security. 3 Credit Hours.

This course covers the theory and practice of computer communications security. Topics include symmetric encryption, public and private key cryptography, message digests, digital signatures, secure email, and various types of authentication methods. We will review various cryptographic primitives, algorithms, intrusion attacks, and security protocols.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

ECE 5538. Hardware and Industrial Control System Security. 3 Credit Hours.

This course covers the theory and practice of hardware and control system security. Topics include digital system security, side channel attacks on cryptographic systems, industrial control system security, and intellectual property protection. We will review hardware implementation of cryptographic primitives, secure hardware design, and security protocols. Note: Credits of this course will not apply to MSEE and PhD (EE) degree programs unless preapproved.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites:

ECE 5528|Minimum Grade of B-|May not be taken concurrently.

ECE 5541. Hardware Security Lab. 3 Credit Hours.

This laboratory includes a university version of wired (with internet protocol suite of packets and layers) and wireless (with IEEE802.11 layers) equipment and physical network along with open source network security software. Depending on the application, the lab provides students flexibility to fully analyze protocols and security vulnerability with respect to the network, Programmable Logic Controller (PLC), and power grid, etc. Students gain hands-on experience from role-playing both as a black-hat hacker by instigating attacks and a white-hat hacker by performing digital forensics and penetration tests. Note: Credits of this course will not apply to MSEE and PhD (EE) degree programs.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

ECE 5548. Secure Computer Memory Architecture and Intrusion Prevention Methodologies. 3 Credit Hours.

This course covers physical computer memory organization and areas of vulnerability such as susceptibility to buffer overflow and Direct Memory Access (DMA) attacks. An overflow attack happens when the data written to a physical memory exceeds its allocated buffer size, which is in violation of memory safety rules. DMA happens when a data transfer is done via direct physical memory access, thus bypassing operating system's supervision. Such a "back door" access is intended to increase the hardware performance throughput but inadvertently creates a major hole in system security. This course analyzes physical memory design methodologies to prevent such intrusions. Note; Credits of this course will not apply to MSEE and PhD (EE) degree programs.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

ECE 5558. Reverse Engineering. 3 Credit Hours.

This course covers methodologies, equipment and software tools used to extract information and build knowledge from sophisticated modern-era hardware and software systems for reverse engineering purposes. Some systems require invasive and destructive technique to get to the source of the information, while for others, non-invasive monitoring and fault injection are sufficient methods. Reverse engineering equipment and tools include but are not limited to debuggers, disassemblers, logic analyzers, oscilloscopes, and simulators. Note: Credits of this course will not apply to MSEE and PhD (EE) degree programs.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

ECE 5562. Wireless Communications Engineering. 3 Credit Hours.

This course provides a comprehensive introduction of physical-layer wireless communications, including: Cellular concepts; Wireless channel modeling; Modulation techniques; Multiple access techniques; Channel coding and wireless system capacity; Receiver diversity; Transmit diversity and multiple-input multiple-output (MIMO) technology; Equalization; Orthogonal frequency division multiplexing (OFDM); Wireless systems and standards, and latest developments in wireless technologies.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

ECE 5564. Cloud Computing Security. 3 Credit Hours.

This course first introduces students to the essentials of a cloud computing environment: technologies, infrastructure, platforms, and application software. Students then build a cloud computing system to monitor its vulnerability, build security measures, and attack it to further refine the security solution. OpenNebula Systems, an open source cloud computing management toolkit and a commercial cloud computing service, will be used for the exercises.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

ECE 5566. Forensics for Cyber Physical Systems Security. 3 Credit Hours.

This course first introduces students to the construct of today's cyber physical system, which is an integration of software and hardware (cyber and physical), built upon an infrastructure of communications network. Cyber physical systems are an integral part of our daily lives that must deliver ultimate safety, security, and reliability, such as in automotive, medical, transportation, power, water, and nuclear energy systems. Therefore, an attack on any such system can be catastrophic. We will analyze hardware components and structure and study their vulnerability to exact forensic artifacts, and why it is important to have trust-worthy hardware, starting from secure integrated circuit design and manufacturing as a baseline. Tools will be used in investigation and forensic analysis. Advanced topics go beyond identification of the attack vector and region, and root causes by researching on self-monitoring, self-repair and self-healing hardware.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

ECE 5568. Engineering Project Quality and Risk Management, and ISO Standards. 3 Credit Hours.

This course covers quality and risk management which are under the umbrella of project management, both go hand-in-hand to ensure best practices for engineering for products. Four components of quality management are quality planning, quality assurance, quality control and quality improvement. Also covered is ISO9001, quality management systems standards. Risk management includes enterprise risk management strategy, risk assessment, risk responses, risk communication and awareness training, and risk acceptance. Also covered is ISO 27001 and 2 on information security standards and best practices.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

ECE 5572. Certificate Preparation - (ISC)2/CISSP-Information Systems Security. 3 Credit Hours.

The International Information Systems Security Certification Consortium (ISC)2 is a non-profit organization that specializes in information security certifications, which demonstrate certificate owners' competence in the subject matter. (ISC)2 is known as the "world's largest IT security organization" and among its certificates, Certified Information Systems Security Professional (CISSP) is the most widely valued. This course covers preparation for the CISSP-ISSEP certification, where ISSEP (Information System Security Engineering Professional) focuses on engineering aspects of the CISSP. The ISSEP exam focuses on four areas of information security: (1) Systems Security Engineering, (2) Certification and Accreditation (C&A) / Risk Management Framework (RMF), (3) Technical Management, and (4) United States Government Information Assurance Related Policies and Issuances. Note: Credits of this course will not apply to MSEE and PhD (EE) degree programs.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

ECE 5574. Certificate Preparation - Cisco Networking Academy. 3 Credit Hours.

This course uses Cisco Networking Academy material to cover various Cisco Certified Network Security topics concentrating on network security principals, tools, and configurations, and includes a hands-on lab equipped with Cisco networking equipment. Note: Credits of this course will not apply to MSEE and PhD (EE) degree programs

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

ECE 5575. Capstone Project. 3 Credit Hours.

A Capstone Project is a work-study project where a student with support from his/her sponsoring entity works on a current or emerging challenge on cybersecurity. Engineering Resilient Systems (ERS) is an example of a DoD sponsored Capstone Project. Through Capstone Project, a student will develop tools and procedures to produce a complete and robust product requirement, make efficient and effective engineering decisions, consider manufacturability of a system design, and establish a baseline resiliency including Tactics, Techniques, and Procedures (TTP) against threats. Note: Credits of this course will not apply to MSEE and PhD (EE) degree programs.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

ECE 5600. Graduate Seminar. 0 Credit Hours.

Required seminar for graduate students in Electrical and Computer Engineering for scientific and professional development. Speakers for these seminars include prominent researchers from academic and professional backgrounds. Students will be graded on participation of at least 70% of the bi-weekly seminars during the semester.

Department Restrictions: Must be enrolled in one of the following Departments: Engineering:Elec Engineering.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may be repeated for additional credit.

ECE 5612. Advanced Processor Systems. 3 Credit Hours.

Hardware description language (Verilog) design of processor systems for digital signal processing and data communication. Projects will be assigned in simulation and synthesis of dataflow and processor architectures targeting field programmable gate arrays (FPGA).

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

ECE 5622. Introduction to Computer Architecture. 3 Credit Hours.

Instruction set architectures, Register Transfer Level hardware description. Data-path design. Controller design. Caches and memory systems. Addressing. Microprogramming. Computer arithmetic. Survey of current computers and microprocessors. Projects will include Verilog/VHDL implementation of data-path components and testing them on FPGAs.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

ECE 5712. Power Systems Engineering. 3 Credit Hours.

This course introduces the modern power systems and its changing landscape. The course covers the basics of power generation and transformers, and an introduction to power electronic devices, AC transmission and distribution, power flow, economic dispatch, transient and stability analysis, short circuit analysis, and HVDC systems, power system protection, power market deregulation.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

ECE 5714. Introduction to Intelligent Systems Engineering. 3 Credit Hours.

Introduction of the use of artificial intelligence techniques to develop intelligent systems. The course gives the student 1) an overview of what artificial intelligence is and its current state; 2) an overview of intelligent systems --what they are and their possible future role in society; 3) a practical and theoretical knowledge of expert systems, their development, implementation and maintenance and 4) an introduction to intelligent tutoring systems and to provide a perspective about the potential impact of these systems.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

ECE 5722. Power Electronic Devices and Systems. 3 Credit Hours.

This course introduces power electronic devices and circuits, and their applications in modern power systems. Topics include DC-DC converters in buck and boost topologies, and their modeling and feedback control; AC-DC rectification and control; DC-AC inverters, modeling, and voltage and frequency control; Three-phase inverters, and HVDC transmission. This course will use Matlab/Simulink simulation for student projects and homeworks.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

ECE 5732. Electric Machines and Drives. 3 Credit Hours.

Fundamentals of electromechanical energy conversion, electric drives and systems. Transformers, DC machines, synchronous machines, induction motors, dq-transformation, vector control of induction motors, reluctance motors, single phase motors, brushless dc motor. Introduction to power electronics and their applications in power drives.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

ECE 5826. Information Theory. 3 Credit Hours.

Information Theory is a field that has been central to the development of modern communications and computing technologies. The goal of this course is to provide the student with a thorough understanding of the concepts of entropy and information, and how to apply these to real world problems such as speech recognition, language engineering, signal compression, and financial modeling. A secondary goal is to develop a mathematically rigorous understanding of methods for measuring and manipulating various measures of information in signals and systems.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites:

ECE 3522|Minimum Grade of B-|May not be taken concurrently.

ECE 5999. Research Experience in Electrical Engineering. 0 Credit Hours.

Research Experience provides graduate students laboratory experiences/research practices prior to undertaking independent, directed, master project, master's thesis, or dissertation research. This course allows graduate students the opportunity to learn the use of laboratory equipment, designing and carrying out an experiment(s), collecting preliminary data, field experiences, and participation in laboratory meeting, etc. with faculty which may lead to identifying a faculty mentor. The course will be graded Pass (P) or Fail (F). The Research Experience is a non-repeatable course. After the completion of ECE 5999 - Research Experience in ECE, students will need to be enrolled in independent study, directed research, master's research, master's thesis, dissertation proposal, or dissertation if they continue in an active research program.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

ECE 8110. Special Topics in Electrical and Computer Engineering. 3 Credit Hours.

Selected advanced topics in various major research areas under electrical and computer engineering.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may be repeated for additional credit.

ECE 8324. Mixed Signal VLSI Design. 3 Credit Hours.

Basic MOS device physics, single state amplifiers, frequency response, op amps, switched capacitor circuits, short-channel effects, amplifier design for wireless communication, low power static RAM architectures, layout and packaging.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites:

ECE 5324|Minimum Grade of C|May not be taken concurrently.

ECE 8334. Nano Applications, MEMS & NEMS. 3 Credit Hours.

Nano challenges, quantum mechanics, nano materials, nanolithography, optics, carbon nanotubes, GaNa nanotechnology, MEMS and NEMS Architectures, Mathematical Model of MEMS and NEMS, Applications of Nanotechnology: Bio-Medical applications, Optical Devices, Sensors.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites:

ECE 5324|Minimum Grade of C|May not be taken concurrently.

ECE 8412. Optimal and Robust Control. 3 Credit Hours.

Concept of optimality, calculus of variations, Euler-Lagrange equation, Pontryagin's minimum principle, Bellman's equation, Kalman filter, uncertainties in physical systems; structured and unstructured uncertainties; application of the Lyapunov method to robust control problems; robust optimal control; state space design for finite and infinite horizon problems; H-infinity design.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites:

ECE 5412|Minimum Grade of C|May not be taken concurrently.

ECE 8414. Adaptive Control. 3 Credit Hours.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

ECE 8512. Signal Processing and Communication Theory. 3 Credit Hours.

Coherent and non-coherent detection of binary and M-ary signals in noise; waveform coding, linear block coding; convolutional, cyclic and turbo codes; error probability and bandwidth-efficiency plane in the design of digital communications systems; multipath and fading channels; simulation of communication systems.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites:

(ECE 5512|Minimum Grade of C|May not be taken concurrently
AND ENGR 5033|Minimum Grade of C|May not be taken concurrently)

ECE 8514. Applications in Digital Signal Processing. 3 Credit Hours.

FIR and IIR digital filter design, finite word length effects, filter banks, multirate signal processing, spectral analysis (classical, modern, parametric and nonparametric techniques), adaptive filtering (Wiener filter theory) and speech production, analysis, and processing tools and speech coding. Computer experiments using MATLAB will be an integral part of the course.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites:

ECE 5033|Minimum Grade of C|May not be taken concurrently.

ECE 8516. Design and Performance of Communication Networks. 3 Credit Hours.

An overview of the technologies, architectures and protocols used to build high-speed communication networks. Design and performance analysis techniques for computer communication networks. Topics will include: design and performance analysis of wired and wireless local networks, sensor networks, and Internet. Projects will include developing stochastic models, queuing analysis, and simulations.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

ECE 8524. Speech Signal Processing. 3 Credit Hours.

Spectral analysis of non-stationary signals, short-time Fourier transform, homomorphic filtering and filter bank, Speech compression, and synthesis techniques. Weiner filtering for speech enhancement.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites:

ECE 8514|Minimum Grade of C|May not be taken concurrently.

ECE 8525. Fundamentals of Speech Recognition. 3 Credit Hours.

This course introduces students to the theory and implementation of modern day speech recognition systems. We begin with a review of pattern recognition and machine learning, including topics such as Gaussian mixture models and Bayesian models. We then discuss the three main components of a speech recognition system: feature extraction, acoustic modeling and language modeling. We conclude the course with an overview of state of the art systems. Students will learn how to simulate and evaluate complex machine learning algorithms such as hidden Markov models and neural networks. Data-driven methodologies will be emphasized.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites:

(ENGR 5022|Minimum Grade of B-|May not be taken concurrently)
AND (ENGR 5033|Minimum Grade of B-|May not be taken concurrently)

ECE 8526. Information Theory. 3 Credit Hours.

Information Theory is a field that has been central to the development of modern communications and computing technologies. The goal of this course is to provide the student with a thorough understanding of the concepts of entropy and information, and how to apply these to real world problems such as speech recognition, language engineering, signal compression, and financial modeling. A secondary goal is to develop a mathematically rigorous understanding of methods for measuring and manipulating various measures of information in signals and systems.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites:

(ENGR 5022|Minimum Grade of B-|May not be taken concurrently)

AND (ENGR 5033|Minimum Grade of B-|May not be taken concurrently)

ECE 8527. Introduction to Machine Learning and Pattern Recognition. 3 Credit Hours.

Pattern recognition theory and practice is concerned with the design, analysis, and development of methods for the classification or description of patterns, objects, signals, and processes. At the heart of this discipline is our ability to infer the statistical behavior of data from limited data sets, and to assign data to classes based on generalized notions of distances in a probabilistic space. Many commercial applications of pattern recognition exist today, including voice recognition, fingerprint classification, and retinal scanners. Recent developments in statistical modeling using Bayesian techniques, neural networks, decision trees, fuzzy logic, and syntactic structures have accelerated the growth of pattern recognition applications. The objective of this course is to introduce fundamental methods of pattern recognition, both statistical and neural, with examples from several application areas.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites:

(ENGR 5022|Minimum Grade of B-|May not be taken concurrently)

AND (ENGR 5033|Minimum Grade of B-|May not be taken concurrently)

ECE 8528. Advanced Topics in Statistical Modeling for Engineering Applications. 3 Credit Hours.

This course builds on a basic knowledge of machine learning and reviews recent advances in the field. It is a research-oriented course intended to complement a student's thesis or dissertation research. The course will focus on a selection of emerging machine learning algorithms and analyze contemporary publications on these techniques. The emphasis will be on algorithms suited to large, complex data sets. Both supervised and unsupervised learning methodologies will be discussed. Applications will be drawn from several signal processing disciplines including speech, image and bioengineering applications.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites:

(ENGR 5022|Minimum Grade of B-|May not be taken concurrently)

AND (ENGR 5033|Minimum Grade of B-|May not be taken concurrently)

AND (ECE 8527|Minimum Grade of B-|May not be taken concurrently)

ECE 8529. Fundamentals of EEG Processing. 3 Credit Hours.

Electroencephalography (EEG) records electrical activity along the scalp, measuring spontaneous electrical activity of the brain. The signals measured along the scalp can be correlated with brain activity, which makes it a primary tool for diagnosis of brain-related illnesses. EEG specialists review these waveforms and develop a diagnosis. EEGs traditionally have been used to diagnose epilepsy and strokes. Other common clinical uses have been for diagnoses of coma, encephalopathies, brain death and sleep disorders. EEGs are increasingly being used to diagnose head-related trauma injuries and Alzheimer's disease. Hence, there is a growing need for expertise to interpret EEGs and, equally important, to understand how these conditions manifest themselves in the EEG signal. In this course we will discuss the techniques neurologists use to manually interpret EEGs. A vast archive of clinical EEG recordings will be studied. Since EEG signals are very low-level electrical signals, we will then discuss digital signal processing that is used to convert the raw electrical signals into visualizations that can be readily interpreted. We will also introduce machine learning techniques that are used to automatically interpret and transcribe these signals.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

ECE 8622. Advanced Computer Architecture. 3 Credit Hours.

Advanced course in the design and analysis of computer architecture. Topics will include instruction level parallelism, digital signal processors, network processors and multi-microprocessors. Projects will focus on the design, design analysis and FPGA implementations of computing systems.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites:

ECE 5322|Minimum Grade of C|May not be taken concurrently.

ECE 8712. Power Systems Operation and Control. 3 Credit Hours.

The emphasis of this course is on computational issues that arise in the analysis and solution of the large-scale operations and control problems in actual power systems. Topics include power flow analysis, contingency analysis, security analysis, load forecasting, economic dispatch, unit commitment, optimal power flow, state estimation, and bad data detection, etc. Additional topics for real time control of power system include substation automation, EMS system architecture, distribution management system (DMS), RTU's and PMU's, and situational awareness and visualization.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites:

ECE 5712|Minimum Grade of B-|May not be taken concurrently.

ECE 8722. Applications of Advanced Power Electronics Technologies. 3 Credit Hours.

In this course, we will start from the basic components and operation principle of power electronic converters and their advanced applications in modern power systems. In particular, the following topics will be included: converter topologies used for grid applications, converter control approaches, AC and DC microgrids, converter interfaced energy storage systems, smart inverters in distribution automation, etc. Applications of power electronic devices and systems used in modern power systems will be presented.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites:

ECE 5722|Minimum Grade of B-|May not be taken concurrently.

ECE 9182. Independent Study I. 3 Credit Hours.

Special study in a particular aspect of engineering under the direct supervision of a graduate faculty member. May be taken once by MS/MSE students and once by Ph.D. students.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may be repeated for additional credit.

ECE 9282. Independent Study II. 3 Credit Hours.

Special study in a particular aspect of engineering under the direct supervision of a graduate faculty member. May be taken once by Ph.D. students.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may be repeated for additional credit.

ECE 9324. VLSI Physical Design. 3 Credit Hours.

This course provides a comprehensive background in the principles and algorithms of VLSI physical design. The algorithms are presented in an intuitive manner so that the student can concentrate on the basic idea of the algorithms. The students are provided enough details to implement the algorithms.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites:

(ECE 8324|Minimum Grade of C|May not be taken concurrently)

AND (ECE 5324|Minimum Grade of C|May not be taken concurrently)

ECE 9412. Nonlinear Control System. 3 Credit Hours.

Modeling of nonlinear systems, types of nonlinearity; Phase Plane Analysis, construction of phase portrait, limit cycle, saddle point; Existence and uniqueness of solutions, sensitivity; Lyapunov Stability, region of attraction, construction of Lyapunov functions; Perturbation Analysis variation of parameters, Method of averaging, Describing Functions, frequency domain analysis; Sliding Mode Control, sliding surface; Feedback Linearization, Lie algebra, state and output linearization, applications.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites:

ECE 8412|Minimum Grade of C|May not be taken concurrently.

ECE 9512. Detection, Estimation, and Modulation Theory. 3 Credit Hours.

Signal detection and estimation in white and non-white noise, MAP estimation, applications in data and telecommunications. Wiener and Kalman-Bucy filters, linear and non-linear modulation.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites:

ENGR 5033|Minimum Grade of C|May not be taken concurrently.

ECE 9514. Adaptive Signal Processing. 3 Credit Hours.

Adaptive filter techniques such as Weiner filter, Linear Prediction, Least-Mean-Square, Recursive Least-Squares, Kalman Filtering algorithms. Introduction to the application of adaptive filters to communications, control, and speech processing.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites:

(ECE 5514|Minimum Grade of C|May not be taken concurrently
AND ECE 8514|Minimum Grade of C|May not be taken concurrently)

ECE 9524. Digital Image Processing. 3 Credit Hours.

P2D digital filters, digital image edge detection and segmentation, feature extraction, deblurring, wavelet transforms, JPEG image compression, Fourier optics.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites:

ECE 8514|Minimum Grade of C|May not be taken concurrently.

ECE 9622. Parallel Processing Architectures. 3 Credit Hours.

This course provides an in-depth study of the design, engineering, and evaluation of modern parallel computers. Design issues covered include: naming, replication, synchronization, latency, overhead, and bandwidth. Other topics include scalable multiprocessors and interconnection network design.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites:

ECE 8612|Minimum Grade of C|May not be taken concurrently.

ECE 9991. Directed Research. 1 to 6 Credit Hour.

Under the guidance of a faculty member, students will select a topic in electro-technology to be researched using at least five references. An extensive research paper must be submitted which will be reviewed by two faculty members. The project report must also be presented at an open seminar. Projects related to industrial applications are encouraged. For non-thesis students only.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may be repeated for additional credit.

ECE 9994. Preliminary Examination Preparation. 1 to 6 Credit Hour.

This course is intended for Ph.D. students who have completed their coursework but who have not yet passed both the Ph.D. Preliminary Examination.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may be repeated for additional credit.

ECE 9995. Project. 1 to 3 Credit Hour.

Under the guidance of a faculty member, students will select a topic in electro-technology to be researched using at least five references. Student present the research at an open seminar, and submits an extensive research paper, which will be reviewed by two faculty members. Projects related to industrial applications are encouraged. For non-thesis students only.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may be repeated for additional credit.

ECE 9996. Thesis. 1 to 3 Credit Hour.

Under the guidance of a faculty member, students will select a topic in electro-technology, and conduct research leading to submission and oral presentation of a thesis proposal and the final defense of the thesis. For thesis students only.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may be repeated for additional credit.

ECE 9998. Pre-Dissertation Research. 1 to 6 Credit Hour.

This course is intended for Ph.D. students who have passed both the Preliminary and Qualifying Examinations but who have not been elevated to candidacy.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may be repeated for additional credit.

ECE 9999. Dissertation Research. 1 to 6 Credit Hour.

This course is intended only for those students who have achieved Ph.D. Candidacy status. A minimum of 6 semester hours is required for graduation.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Student Attribute Restrictions: Must be enrolled in one of the following Student Attributes: Dissertation Writing Student.

Repeatability: This course may be repeated for additional credit.