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

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

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

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

### Degrees Offered
- Master of Science in Electrical Engineering
- Master of Science in Computer Engineering
- Master of Science in Computer Engineering and Electrical Engineering (dual degree)
- Master of Biomedical Imaging and Signals
- Master of Electrical and Computer Engineering
- Master of Network Engineering
- Master of Power Engineering
- Master of VLSI and Microelectronics
- Doctor of Philosophy in Electrical Engineering
- Doctor of Philosophy in Computer Engineering

### Joint Degree Programs
- With the Department of Computer Science: Master of Telecommunications and Software Engineering
- With the Center for Financial Markets: Master of Electricity Markets

### Interdisciplinary Programs
- Master of Science in Electrical Engineering with specialization in Energy/Environment/Economics (E³)
- Master of Electrical and Computer Engineering with specialization in Energy/Environment/Economics (E³)

### Certificate Programs
- Advanced Electronics
- Applied Electromagnetics
- Communication Systems
- Computer Engineering
- Control Systems
- Electricity Markets
- Power Electronics
- Power Engineering
- Signal Processing
- Wireless Communications Engineering
Research Centers and Facilities

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

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

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

Research Areas

Active research programs are conducted in the general areas of communications systems, wireless networks, computer systems, computer networks, wireless security, cloud computing and micro-electronics; electromagnetics and electronics; power and control systems; signal and image processing.
Faculty

Anjali, Tricha, Associate Professor of Electrical and Computer Engineering. B.S., M.S., Indian Institute of Technology; Ph.D., Georgia Institute of Technology. Wireless networks, network security, network routing, multipath routing, network optimization, remote education.

Arzbacher, Robert, Emeritus Professor of Electrical and Computer Engineering. Ph.D., University of Illinois, Urbana-Champaign. Instrumentation, signal processing and control.

Atkin, Guillermo E., Associate Professor of Electrical and Computer Engineering. B.S., Universidad F. Santa Maria (Chile); Ph.D., University of Waterloo (Canada). Modulation and coding, digital mobile and wireless communication, spread spectrum and optical communication systems.

Borkar, Suresh, Senior Lecturer of Electrical and Computer Engineering. B. Tech Indian Institute of Technology (India); M.S., Ph.D., Illinois Institute of Technology. Wireless and wireline telecommunications, operating systems, architecture, and performance of computer and network systems.

Brankov, Jovan G., Associate Professor of Electrical and Computer Engineering. Diploma, University of Belgrade (Serbia); M.S., Ph.D., Illinois Institute of Technology. Medical imaging, image sequence processing, pattern recognition and data mining.

Brown, Ian, Assistant Professor of Electrical and Computer Engineering. B.S., Swarthmore College; M.S., Ph.D., University of Wisconsin-Madison. Design and modeling of electric machines, adjustable speed drives, and power electronics applied to renewable energy systems and energy efficient power conversion.

Cheng, Yu, Associate Professor of Electrical and Computer Engineering. B.E., M.E., Tsinghua University (China); Ph.D. University of Waterloo (Canada). Wireless networks, network security, network measurement, and wireless/wireline interworking.

Choi, Kyuwon, Associate Professor of Electrical and Computer Engineering. B.S., M.S., KyungHee University (Korea); Ph.D., Georgia Institute of Technology. VLSI design and automation for low power.

El Rouayheb, Salim, Assistant Professor of Electrical and Computer Engineering. Dipl., Lebanese University; M.S., American University of Beirut; Ph.D., Texas A&M University. Information theory, coding theory, coding for distributed data storage systems, data security, wireless communications.

Flueck, Alexander J., Associate Professor of Electrical and Computer Engineering. B.S., M.E., Ph.D., Cornell University. Power systems, high performance computing, autonomous agent-based control.

Khokhar, Ashfaq A., Professor of Electrical and Computer Engineering and Chair. B.Sc., University of Engineering and Technology and Chair. B.Sc., University of Engineering and Technology (Pakistan); M.S., Syracuse University; Ph.D., University of Southern California, Los Angeles. High performance computing, big data analytics, wireless networks, embedded systems, multimedia systems.

Kim, Joohee, Assistant Professor of Electrical and Computer Engineering. B.S., M.S., Yonsei University (Korea); Ph.D., Georgia Institute of Technology. Multimedia signal processing, multimedia communications and networking, computer vision.

Kirshnamurthy, Mahesh, Associate Professor of Electrical and Computer Engineering. B.E., Amrawati University (India); M.S., University of Missouri- Rolla; Ph.D., University of Texas-Arlington. Power electronics, electric machines, adjustable speed drives and energy storage, systems for renewable energy, and automotive applications.

Li, Zuyi, Professor of Electrical and Computer Engineering and Associate Director of the Galvin Center for Electricity Innovation. B.S., Shanghai Jiaotong University; M.S., Tsinghua University; Ph.D., Illinois Institute of Technology. Market operation of electric power system and integration of renewable energy, smart grid, power system protection.

Modir Shanechi, Hassan, Senior Lecturer of Electrical and Computer Engineering. B.S., M.S., Tehran University (Iran); Ph.D., Michigan State University. Nonlinear and intelligent systems, power system dynamics and security.

Oruklu, Erdal, Associate Professor of Electrical and Computer Engineering. B.S., Technical University of Istanbul (Turkey); M.S., Bogazici University (Turkey); Ph.D., Illinois Institute of Technology. VLSI and SoC design, signal processing architectures, digital arithmetic, computer systems.

Saletta, Gerald F., Emeritus Professor of Electrical and Computer Engineering. B.S., M.S., University of Notre Dame; Ph.D., Illinois Institute of Technology. Electronics, digital systems.

Sanie, Jafar, Filmer Professor of Electrical and Computer Engineering and Associate Chair. B.S., University of Maryland; M.S., Case Western Reserve University; Ph.D., Purdue University. Embedded computing, DSP architectures, signal and image processing, detection and estimation, ultrasonic imaging for both medical and industrial applications.
Shahidehpour, Mohammad, Bodine Professor of Electrical and Computer Engineering, Director of the Galvin Center for Electricity Innovation, and Associate Director of the Wanger Institute for Sustainable Energy Research (WISER). B.S., Arya-Mehr University of Technology (Iran); M.S., Ph.D., University of Missouri-Columbia. Large-scale power systems, nonlinear stochastic systems, optimization theory.

Shen, Zheng John, Grainger Professor of Electrical and Computer Engineering. B.S., Tsinghua University (China); M.S., Ph.D., Rensselaer Polytechnic Institute.


Wang, Jia, Associate Professor of Electrical and Computer Engineering. B.S., Tsinghua University (China); M.S., Ph.D., Northwestern University. VLSI, design automation, and algorithm design.

Weber, Erwin W., Emeritus Professor of Electrical and Computer Engineering. B.S., M.S., Ph.D., Illinois Institute of Technology. Electromagnetics, RF electronics, antenna theory.

Wernick, Miles, Motorola Professor of Electrical and Computer Engineering and Director of Medical Imaging. B.A., Northwestern University; Ph.D., University of Rochester. Medical imaging, image processing, and pattern recognition.

Williamson, Geoffrey A., Professor of Electrical and Computer Engineering and Associate Dean for Analytics in the Armour College of Engineering. B.S., M.S., Ph.D., Cornell University. Parameter estimation and system identification, adaptive signal processing and control, control systems.

Wong, Thomas Tang Yum, Professor of Electrical and Computer Engineering. B.S., University of Hong Kong; M.S., Ph.D., Northwestern University. Applied electromagnetics, microwave and terahertz measurements, nanoscale structures and devices.

Xu, Yang, Associate Professor of Electrical and Computer Engineering. B.S., M.S., Fudan University (China); Ph.D., Carnegie Mellon University. RFIC design for digital communications and wireless medical technology.

Yang, Yongyi, Harris Perlstein Professor of Electrical and Computer Engineering and Biomedical Engineering. B.S.E.E., M.S.E.E., Northern Jiatong University (China); M.S., Ph.D., Illinois Institute of Technology. Image and signal processing, data compression, applied mathematical and statistical methods.

Zhou, Chi, Associate Professor of Electrical and Computer Engineering. B.S., Tsinghua University (China), M.S., Ph.D., Northwestern University. Wireless sensor networks for smart grid application, scheduling for OFDM/MIMO systems, network coding for wireless mesh networks, integration of optical and wireless networks.
Electrical and Computer Engineering

Admission Requirements

Cumulative undergraduate GPA minimum: 3.0/4.0

1. GRE score: M.S./MAS: 1100 (quantitative + verbal) 3.5 (analytical writing)
2. New GRE score: M.S./MAS: 304 (quantitative + verbal) 3.5 (analytical writing)
1. GRE score: Ph.D.: 1100 (quantitative + verbal) 3.5 (analytical writing)
2. New GRE score: Ph.D.: 304 (quantitative + verbal) 3.5 (analytical writing)

TOEFL minimum score: 550/213/80*

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

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

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

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

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

*Paper-based test score/computer-based test score/internet-based test score.
Master of Science in Electrical Engineering

32 credit hours
Thesis option

The purpose of this degree is to prepare students for advanced study and industry in the field of electrical engineering. The Master of Science in Electrical Engineering (M.S.E.E.) is a degree program combining breadth across several areas of study within electrical engineering and specialization within one area, which includes an option to pursue thesis research under the guidance of a faculty advisor. Areas of study include communication and signal processing; computers and microelectronics; and power and control systems. The program is normally completed in three semesters of full-time study.

The admission requirements for this degree follow the existing admission requirements for Master’s degrees in the ECE department. Students whose accredited B.S. degree is not in electrical engineering may pursue the M.S.E.E., provided that they have an adequate background and can demonstrate proficiency in the material contained in undergraduate courses equivalent to IIT’s ECE 211 and ECE 213 (Circuit Analysis I and II), ECE 218 (Digital Systems), ECE 307 (Electrodynamics), ECE 308 (Signals and Systems), ECE 311 (Engineering Electronics), MATH 251 (Multivariate and Vector Calculus), and MATH 252 (Introduction to Differential Equations). A student may demonstrate proficiency by successfully completing the courses or by satisfactory performance in one or more special examinations administered by the department.

The program of study includes a minimum of 32 credit hours of acceptable graduate coursework, with a minimum of 20 credit hours of ECE courses at the 500-level or higher. Up to six credits of ECE short courses may be applied to the degree.

Students, with advisor approval, select courses appropriate to their needs and interests. The program of study must include a minimum of four courses within one of the electrical engineering (EE) areas of concentration listed on the next page and a minimum of two courses from the other areas. An M.S.E.E. candidate may, with permission of a thesis advisor, include in his or her program a thesis of six to eight credit hours. The master’s thesis is recommended for pre-doctoral students. The thesis option requires a written thesis and an oral defense of the thesis. Thesis format and deadlines are set by the Graduate College.
EE Areas of Concentration

I. Communications and Signal Processing

- ECE 401 Communication Electronics
- ECE 403 Digital and Data Communication Systems
- ECE 404 Digital and Data Communication Systems with Laboratory
- ECE 406 Introduction to Wireless Communication Systems
- ECE 421 Microwave Circuits and Systems
- ECE 423 Microwave Circuits and Systems with Laboratory
- ECE 436 Digital Signal Processing I with Laboratory
- ECE 437 Digital Signal Processing I
- ECE 481 Image Processing
- ECE 504 Wireless Communication System Design
- ECE 507 Imaging Theory and Applications
- ECE 508 Video Communications
- ECE 509 Electromagnetic Field Theory
- ECE 511 Analysis of Random Signals
- ECE 513 Communication Engineering Fundamentals
- ECE 514 Digital Communication Principles
- ECE 515 Modern Digital Communications
- ECE 516 Coding for Distributed Storage Systems
- ECE 519 Coding for Reliable Communications
- ECE 522 Electromagnetic Compatibility
- ECE 565 Computer Vision and Image Processing
- ECE 566 Statistical Pattern Recognition
- ECE 567 Statistical Signal Processing
- ECE 568 Digital Speech Processing
- ECE 569 Digital Signal Processing II
- ECE 570 Fiber Optic Communication Systems
- ECE 576 Antenna Theory
- ECE 578 Microwave Theory

II. Computers and Microelectronics

- ECE 407 Introduction to Computer Networks with Laboratory
- ECE 408 Introduction to Computer Networks
- ECE 415 Solid-State Electronics
- ECE 425 Analysis and Design of Integrated Circuits
- ECE 429 Introduction to VLSI Design
- ECE 441 Microprocessors
- ECE 443 Introduction to Computer Security
- ECE 446 Advanced Logic Design
- ECE 449 Object-Oriented Programming and Computer Simulation
- ECE 485 Computer Organization and Design
- ECE 502 Basic Network Theory
- ECE 521 Quantum Electronics
- ECE 524 Advanced Electronic Circuit Design
- ECE 525 RF Integrated Circuit Design
- ECE 526 Active Filter Design
- ECE 527 Performance Analysis of RF Integrated Circuits
- ECE 529 Advanced VLSI Systems Design
- ECE 530 High Performance VLSI/IC Systems
- ECE 541 Performance Evaluation of Computer Networks
- ECE 542 Design and Optimization of Computer Networks
- ECE 543 Computer Network Security
- ECE 544 Wireless and Mobile Networks
- ECE 545 Advanced Computer Networks
- ECE 546 Wireless Network Security
- ECE 547 Wireless Networks Performance Analysis
- ECE 571 Nanodevices and Technology
- ECE 575 Electron Devices
- ECE 583 High Speed Computer Arithmetic
- ECE 584 VLSI Architectures for Signal Processing and Communication Systems
- ECE 585 Advanced Computer Architecture
- ECE 586 Fault Detection in Digital Circuits
- ECE 587 Hardware/Software Codeign
- ECE 588 CAD Techniques for VLSI Design
- ECE 589 Computer-Aided Design of Analog IC

III. Power and Control

- ECE 411 Power Electronics
- ECE 412 Electric Motor Drives
- ECE 417 Power Distribution Engineering
- ECE 418 Power Systems Analysis
- ECE 419 Power Systems Analysis with Laboratory
- ECE 420 Analytical Methods in Power Systems
- ECE 438 Control Systems
- ECE 505 Applied Optimization for Engineers
- ECE 506 Analysis of Nonlinear Systems
- ECE 531 Linear System Theory
- ECE 535 Discrete Time Systems
- ECE 538 Renewable Energies
- ECE 539 Computer Aided Design of Electric Machines
- ECE 540 Reliability Theory and System Implementation
- ECE 548 Energy Harvesting
- ECE 549 Motion Control Systems Dynamics
- ECE 550 Power Electronic Dynamics and Control
- ECE 551 Advanced Power Electronics
- ECE 552 Adjustable Speed Drives
- ECE 553 Power System Planning
- ECE 554 Power System Relaying
- ECE 555 Power Market Operations
- ECE 556 Power Market Economics and Security
- ECE 557 Fault-Tolerant Power Systems
- ECE 558 Power System Reliability
- ECE 559 High-Voltage Power Transmission
- ECE 560 Power Systems Dynamics and Stability
- ECE 561 Deregulated Power Systems
- ECE 562 Power System Transaction Management
- ECE 563 Computational Intelligence in Engineering
- ECE 564 Control and Operation of Electric Power Systems
- ECE 580 Elements of Sustainable Energy
- ECE 581 Elements of Smart Grid
- ECE 582 Microgrid Design and Operation
Master of Science in Computer Engineering

32 credit hours
Thesis option

The purpose of this degree is to prepare students for advanced study and/or research or industrial practice in the field of computer engineering. The Master of Science in Computer Engineering (M.S.CP.E.) program builds a strong foundation in all aspects of the design and development of computer systems, with a specialization in a major area. Students have the option to pursue thesis research under the guidance of a faculty advisor. Areas of study include computer hardware design, computer networking and telecommunications, and computer system and application software. The program is normally completed in three semesters of full-time study.

The admission requirements for this degree follow the existing admission requirements for master’s degrees in the ECE Department. Students whose accredited B.S. degree is not in computer engineering may pursue the M.S.CP.E., provided that they have an adequate background and can demonstrate proficiency in the material contained in the following undergraduate courses: ECE 211 and ECE 213 (Circuit Analysis I and II), ECE 218 (Digital Systems), ECE 242 or CS 350 (Digital Computers and Computing), ECE 311 (Engineering Electronics), CS 201 (i.e., CS 115 and CS 116 combined, Object Oriented Programming I-II), CS 401 (Introduction to Advanced Studies in CS), MATH 251 (Multivariate and Vector Calculus), and MATH 252 (Introduction to Differential Equations). A student may demonstrate proficiency by successfully completing the courses or by demonstrating satisfactory performance in one or more special examinations administered by the department.

The program of study includes a minimum of 32 credit hours of acceptable graduate coursework, with a minimum of 21 credit hours of ECE coursework. A minimum of 20 credit hours must be taken at the 500-level or higher. Up to six credits of ECE short courses may be applied to the degree. Students, with advisor approval, select courses appropriate to their needs and interests. The program of study must include two core and two elective courses within one of the following computer engineering (CPE) areas of concentration, and at least one core course from the remaining two areas. An M.S.CP.E candidate may, with permission of a thesis advisor, include in his or her program a thesis of six to eight credit hours. The master’s thesis is strongly recommended for pre-doctoral students. The thesis option requires a written thesis and an oral defense of the thesis. Thesis format and deadlines are set by the Graduate College.
CPE Areas of Concentration

### I. Computer Hardware Design

#### Core Courses
- ECE 529 Advanced VLSI Systems Design
- AND/OR
- ECE 429 Introduction to VLSI Design
- AND
- ECE 585 Advanced Computer Architecture

#### Elective Courses
- ECE 425 Analysis and Design of Integrated Circuits
- ECE 429 Introduction to VLSI Design
- ECE 441 Microcomputers
- ECE 446 Advanced Logic Design
- ECE 485 Computer Organization and Design
- ECE 529 Advanced VLSI Systems Design
- ECE 530 High Performance VLSI/IC Systems
- ECE 583 High Speed Computer Arithmetic
- ECE 584 VLSI Architectures for Signal Processing and Communications
- ECE 585 Advanced Computer Architecture
- ECE 586 Fault Detection in Digital Circuits
- ECE 587 Hardware/Software Codesign
- ECE 588 CAD Techniques for VLSI Design
- ECE 589 Computer Aided Design of Analog IC

### II. Computer Systems Software

#### Core Courses
- CS 550 Comparative Operating Systems
- CS 551 Operating System Design and Implementation

#### Elective Courses
- ECE 449 Object-Oriented Programming and Computer Simulation
- ECE 587 Hardware/Software Codesign
- CS 487 Software Engineering I
- CS 545 Distributed Computing Landscape
- CS 546 Parallel and Distributed Processing
- CS 550 Advanced Operating Systems
- CS 551 Operating System Design and Implementation
- CS 555 Analytic Models and Simulation of Computer Systems
- CS 586 Software Systems Architectures
- CS 587 Software Project Management
- CS 588 Advanced Software Engineering Development
- CS 589 Software Testing and Analysis

### III. Networks and Telecommunications

#### Core Courses
- ECE 407 Introduction to Computer Networks with Laboratory
- OR
- ECE 408 Introduction to Computer Networks
- ECE 443 Introduction to Computer Security
- ECE 504 Wireless Communication System Design
- ECE 508 Video Communications
- ECE 511 Analysis of Random Signals
- ECE 513 Communication Engineering Fundamentals
- ECE 514 Digital Communication Principles
- ECE 515 Modern Digital Communications
- ECE 519 Coding for Reliable Communications
- ECE 541 Performance Evaluation of Computer Networks
- ECE 542 Design and Optimization of Computer Networks
- CS 455 Data Communications

#### Elective Courses
- ECE 407 Introduction to Computer Networks with Laboratory
- ECE 408 Introduction to Computer Networks
- ECE 443 Introduction to Computer Security
- ECE 444 Wireless and Mobile Networks
- ECE 455 Advanced Computer Networks
- ECE 456 Wireless Network Security
- ECE 457 Wireless Networks Performance Analysis
- ECE 570 Fiber Optic Communication Systems
- ECE 584 VLSI Architectures for Signal Processing and Communications
- CS 455 Data Communications
- CS 544 Computer Networks II: Network Services
Master of Science in Computer Engineering and Electrical Engineering

Dual Degree, 45 credit hours
Thesis Option

The purpose of the Master of Science in Computer Engineering and Electrical Engineering (M.S.CP.E./E.E.) is to prepare students for advanced study and/or research, or for industry in the fields of both computer and electrical engineering. The M.S.CP.E./E.E. program provides for a strong foundation in all aspects of the design and development of computer systems, and also offers several areas of study within electrical engineering. There is also an option to pursue thesis research under the guidance of a faculty advisor.

There is a growing need for engineers with a strong educational background in both computer engineering and electrical engineering. In the M.S.CP.E./E.E. program, students will be introduced to topics important to the computer engineering field, such as computer hardware design, computer networks, and software engineering, as well as topics in electrical engineering, such as communications and signal processing, electronics and electromagnetics, and power and control systems. The program of study includes a minimum of 45 credit hours of acceptable graduate coursework in both computer engineering and electrical engineering. M.S.CP.E./E.E. degree requirements are described in the section below. Requirements for the M.S.CP.E./E.E. fully satisfy the existing requirements for an M.S. in Computer Engineering and an M.S. in Electrical Engineering. The program is usually completed in four semesters of full-time study.

Admission requirements for the M.S.CP.E./E.E. are the same as those for admission to the Master of Science in Computer Engineering or Electrical Engineering. Students whose accredited B.S. degree is not in computer and/or electrical engineering may pursue the CPE/EE degree provided that they demonstrate proficiency in the material contained in the following undergraduate courses: ECE 211 and ECE 213 (Circuit Analysis I and II), ECE 218 (Digital Systems), ECE 242 or CS 350 (Digital Computers and Computing), ECE 307 (Electrodynamics), ECE 308 (Signals and Systems), ECE 311 (Engineering Electronics), CS 201 (i.e., CS 115 and CS 116 combined, Object Oriented Programming I-II), CS 401 (Introduction to Advanced Studies in CS), MATH 251 (Multivariate and Vector Calculus), and MATH 252 (Introduction to Differential Equations). A student may demonstrate proficiency by successfully completing the courses or by demonstrating satisfactory performance in one or more special examinations administered by the department.

The description of the CPE areas of concentration is in the Master of Science in Computer Engineering section. A description of the EE areas of concentration is in the Master of Science in Electrical Engineering section.

In addition to all university requirements for a Master of Science degree, the M.S.CP.E./E.E. degree has the following requirements:

1. A minimum of 45 credit hours of graduate level coursework including the following:
   (a) Two core courses in a CPE major area, chosen from among the CPE areas of concentration.
   (b) Two elective courses in the CPE major area, chosen from among the CPE areas of concentration.
   (c) One core course from each of the two remaining areas of CPE concentration.
   (d) Four (or more) courses within an EE major area, chosen from among the EE areas of concentration (Areas I, II, and III).
   (e) A minimum of two courses from two EE minor areas, chosen from among Areas I, II, and III outside the major.
   (f) Additional coursework approved by the academic advisor.

2. A GPA of at least 3.0/4.0 (excluding prerequisites and proficiencies).

The CPE/EE program is subject to the following restrictions: a minimum of 30 credit hours course work at the 500-level or higher; at least 30 credit hours of ECE courses, excluding short courses; no more than six credit hours of ECE short courses; six to eight credit hours of research work (ECE 591) leading to an M.S. dissertation may be included with the approval of a thesis advisor.

Each regular (matriculated) graduate student is assigned an academic advisor, indicated in his/her formal letter of admission to the master’s program.

Students should consult with their academic advisor to file a program of study meeting these requirements within three months after initial registration for full-time students, and prior to enrolling beyond 12 credits for part-time students.
Master of Biomedical Imaging and Signals

30 credit hours

The purpose of this degree program is to prepare students for leading edge positions in industry in the areas of biomedical imaging and signal processing. The Professional Master of Biomedical Imaging and Signals is a course-only degree program that prepares students for professional practice.

The interdisciplinary nature of bioengineering generally involves many facets of electrical and computer engineering. The Department of Electrical and Computer Engineering offers several courses and research opportunities that engage students interested in biomedical engineering. In addition, there are significant number of courses offered by the Biomedical Engineering Department and other disciplines at IIT which are of great importance to students interested in the professional master’s degree in biomedical engineering, with specialization in medical imaging and bio-signals.

The admission requirements for the degree follow the existing admission requirements for other professional master’s degrees in the ECE Department. Students whose accredited B.S. degree is not in electrical and computer engineering may pursue the professional master’s degree provided that they have an adequate background and can demonstrate proficiency in the material contained in undergraduate courses equivalent to IIT’s: ECE 211 and ECE 213 (Circuit Analysis I and II), ECE 218 (Digital Systems), ECE 307 (Electrodynamics), ECE 308 (Signals and Systems), ECE 311 (Engineering Electronics), BIOL 107 (General Biology Lectures), MATH 251 (Multivariate and Vector Calculus), MATH 252 (Introduction to Differential Equations), and MATH 474 (Probability and Statistics). A student may demonstrate proficiency by successfully completing the courses or by demonstrating satisfactory performance in one or more special examinations administered by the department.

Students can pursue a professional master’s degree in the area of Biomedical Imaging and Signals by completing the required core and elective courses, including at least two ECE and one BME elective courses.

Curriculum

Required Courses

ECE 481 Image Processing
AND/OR
ECE 565 Computer Vision and Image Processing
ECE 437 Digital Signal Processing I
AND/OR
ECE 569 Digital Signal Processing II
ECE 511 Analysis of Random Signals
BIOL 430 Animal Physiology
OR
BME 450 Animal Physiology

Imaging Elective Courses (1 course minimum)

ECE 507 Imaging Theory and Applications
BME 430 Concepts of Medical Imaging
BME 532 Medical Imaging Science
BME 535 Magnetic Resonance Imaging
BME 537 Introduction to Molecular Imaging
BME 538 Neuroimaging

Signals Elective Courses (2 courses minimum)

ECE 505 Applied Optimization for Engineers
ECE 566 Statistical Pattern Recognition
ECE 567 Statistical Signal Processing
ECE 568 Digital Speech Processing
ECE 597 Special Project in Biomedical Imaging and Signals
BME 501 Biomedical Instrumentation
BME 551 Physiological Signal Processing & Control Theory I
BME 552 Control Systems for Biomedical Engineers

With advisor’s approval, students may take up to two senior (400 level) or graduate level courses in Engineering, Math, or Science.
Master of Electrical and Computer Engineering

30 Credit hours

The purpose of this degree is to prepare students for leading edge positions in industry in the fields of electrical and computer engineering. The Master of Electrical and Computer Engineering (M.E.C.E.) is a course only degree program that prepares students for professional practice in electrical and computer engineering. The program can be completed in one year of full-time study.

The admission requirements for this degree follow the existing admission requirements for a Master’s degree in the ECE department. Student’s whose accredited B.S. degree is not in electrical engineering may pursue the M.E.C.E., provided that they have an adequate background and can demonstrate proficiency in the material contained in undergraduate courses equivalent to IIT’s: ECE 211 and ECE 213 (Circuit Analysis I and II), ECE 218 (Digital Systems), ECE 307 (Electrodynamics), ECE 308 (Signals and Systems), ECE 311 (Engineering Electronics), MATH 251 (Multivariate and Vector Calculus), and MATH 252 (Introduction to Differential Equations). A student may demonstrate proficiency by successfully completing the courses or by demonstrating satisfactory performance in one or more special departmental examinations administered by the department.

The program of study includes a minimum of 30 credit hours of acceptable graduate coursework, with a minimum of 24 credit hours in electrical and computer engineering, and a minimum of 18 credit hours at the 500-level or higher. Up to six credits of ECE short courses may be applied to the degree. Students arrange their program of study with their advisor’s approval and typically elect to build their program to emphasize one or more areas of specialization. No formal distribution requirements are imposed. Areas of specialization include communication systems, computer communication, computer engineering, power electronics, electromagnetics, electronics, VLSI and microelectronics, power systems, and signal and image processing.
Master of Network Engineering

30 credit hours

The Master of Network Engineering (M.N.E.) is a course only degree program that prepares students for professional practice in network engineering and information technologies. The M.N.E. is a focused professional master's degree requiring a minimum of 30 credit hours of advisor approved coursework. The program offered by the Department of Electrical and Computer Engineering (ECE) can be completed in one year of full-time study.

The admission requirements for this degree follow the existing admission requirements for master's degree in the ECE department. A person holding a B.S.E.E. or a B.S.CP.E degree has the necessary background to undertake the M.N.E. program. A student without adequate background is required to demonstrate proficiency in the following courses: ECE 211 (Circuit Analysis I), ECE 213 (Circuit Analysis II), ECE 308 (Signals and Systems), MATH 251 (Multivariate and Vector Calculus), MATH 252 (Introduction to Differential Equations), and MATH 474 (Probability). A student may demonstrate proficiency by successfully completing the courses or by demonstrating satisfactory performance in one or more special examinations administered by the department.

The M.N.E. program of study must include a minimum of 24 credit hours of ECE coursework, 12 credit hours of required core courses, 12 credit hours of MNE elective courses, and 6 credit hours of advisor approved elective courses. At least 18 credit hours of the courses must be at the 500 level. A maximum of 6 credit hours may be taken from ECE 700 level short courses.

Curriculum

Required Courses (12 credit hours)

Both of the following:
- ECE 511 Analysis of Random Signals
- ECE 513 Communication Engineering Fundamentals

One of the following:
- ECE 407 Introduction to Computer Networks with Laboratory
- ECE 408 Introduction to Computer Networks
- ECE 545 Advanced Computer Networks

Elective Courses (12 credit hours)

This coursework is taken from the 400-, and 500-level courses listed below, and approved by the faculty advisor. A maximum of 6 credit hours of ECE short courses can be included in the M.N.E. program of studies.

- ECE 403 Digital and Data Communication Systems
- ECE 405 Digital and Data Communication Systems with Laboratory
- ECE 406 Introduction to Wireless Communication Systems
- ECE 437 Digital Signal Processing I
- ECE 436 Digital Signal Processing I with Laboratory
- ECE 443 Introduction to Computer Security
- ECE 485 Computer Organization and Design
- ECE 504 Wireless Communication System Design
- ECE 508 Video Communications
- ECE 514 Digital Communication Principles
- ECE 515 Modern Digital Communications
- ECE 516 Coding for Distributed Storage Systems
- ECE 519 Coding for Reliable Communications
- ECE 541 Performance Evaluation of Computer Networks
- ECE 542 Design and Optimization of Computer Networks
- ECE 543 Computer Network Security
- ECE 544 Wireless and Mobile Networks
- ECE 545 Advanced Computer Networks
- ECE 546 Wireless Network Security
- ECE 547 Wireless Networks Performance Analysis
- ECE 565 Computer Vision and Image Processing
- ECE 568 Digital Speech Processing
- ECE 569 Digital Signal Processing II
- ECE 570 Fiber-Optic Communication Systems
- ECE 583 High Speed Computer Arithmetic
- ECE 584 VLSI Architectures for Signal Processing and Communications
- ECE 585 Digital Computer Design
- CS 455 Data Communications
- CS 548 Broadband Networks
Master of Power Engineering

30 credit hours

The purpose of this degree program is to prepare students for leading edge positions in industry in the areas of electric power, power electronics, motor drives, and electric machines. The Professional Master of Power Engineering is a course-only degree program that prepares students for professional practice in power engineering.

The admission requirements for this degree follow the existing admission requirements for other professional master’s degrees in the ECE department. Students whose accredited B.S. degree is not in electrical engineering may pursue the professional master’s degree, provided that they have an adequate background and can demonstrate proficiency in the material contained in undergraduate courses equivalent to IIT’s: ECE 211 and ECE 213 (Circuit Analysis I and II), ECE 311 (Engineering Electronics), ECE 319 (Fundamentals of Power Engineering), MATH 251 (Multivariate and Vector Calculus), and MATH 252 (Introduction to Differential Equations). A student may demonstrate proficiency by successfully completing the courses or by demonstrating satisfactory performance in one or more special examinations administered by the ECE department.

The program of study includes a minimum of 30 credit hours of acceptable coursework with a minimum of 24 credit hours from the following list of core and elective courses (up to 6 credit hours may be selected from other ECE courses). A minimum of 18 credit hours at the 500-level or higher must be selected. Up to 3 credit hours of a Graduate Special Project in power engineering (ECE 594 or ECE 597), and up to 6 credit hours of ECE short courses may be applied to the degree.

Curriculum

Core Courses (3 courses minimum)
ECE 411 Power Electronics
ECE 412 Electric Motor Drives
ECE 420 Analytical Methods in Power Systems
ECE 551 Advanced Power Electronics

One of the following:
ECE 418 Power Systems Analysis
ECE 419 Power Systems Analysis with Laboratory

Elective Courses in Power Systems (2 courses minimum)
ECE 417 Power Distribution Engineering
ECE 553 Power System Planning
ECE 554 Power System Relaying
ECE 555 Power Market Operations
ECE 556 Power Market Economics and Security
ECE 557 Fault-Tolerant Power Systems
ECE 558 Power System Reliability
ECE 559 High-Voltage Power Transmission
ECE 560 Power Systems Dynamics and Stability
ECE 561 Deregulated Power Systems
ECE 562 Power System Transaction Management
ECE 563 Computational Intelligence in Engineering
ECE 564 Control and Operation of Electric Power Systems
ECE 580 Elements of Sustainable Energy
ECE 581 Elements of Smart Grid
ECE 582 Microgrid Design and Operation
CHE 543 Energy, Environment, and Economics

Elective Courses in Power Electronics and Motor Drives (2 courses minimum)
ECE 437 Digital Signal Processing I
ECE 438 Control Systems
ECE 531 Linear System Theory
ECE 538 Renewable Energies
ECE 539 Computer Aided Design of Electric Machines
ECE 548 Energy Harvesting
ECE 549 Motion Control Systems Dynamics
ECE 550 Power Electronic Dynamics and Control
ECE 552 Adjustable Speed Drives
ECE 764 Vehicular Power Systems
CHE 541 Renewable Energy Technologies
Master of VLSI and Microelectronics

30 credit hours

The purpose of this degree program is to prepare students for leading edge positions in industry in the areas of VLSI and microelectronics. The Professional Master of VLSI and Microelectronics is a course-only degree program that prepares students for professional practice.

The admission requirements for this degree follow the existing admission requirements for other professional master’s degrees in the ECE department. Students whose accredited B.S. degree is not in electrical engineering may pursue the professional master’s degree, provided that they have an adequate background and can demonstrate proficiency in the material contained in undergraduate courses equivalent to IIT’s: ECE 211 and ECE 213 (Circuit Analysis I and II), ECE 218 (Digital Systems), ECE 307 (Electrodynamics), ECE 308 (Signals and Systems), ECE 311 (Engineering Electronics), MATH 251 (Multivariate and Vector Calculus), and MATH 252 (Introduction to Differential Equations).

A student may demonstrate proficiency by successfully completing the courses or by demonstrating satisfactory performance in one or more special examinations administered by the ECE department.

The program of study includes a minimum of 30 credit hours of acceptable coursework. Students can pursue a professional master’s degree in the area of VLSI and microelectronics by completing the required core courses: ECE 425, ECE 429, ECE 529, and ECE 575 (and/or ECE 415) and selecting 6 additional courses from a combination of computer engineering electives, electronics electives, and other areas in electrical and computer engineering. A minimum of 18 credit hours at the 500-level or higher must be selected. With advisor approval the student may take up to two ECE courses in other areas of electrical and computer engineering, such as signal processing, communications, power and control.

Curriculum

Core Courses (4 courses minimum)
- ECE 415 Solid-State Electronics
- ECE 575 Electron Devices
- AND/OR
- ECE 425 Analysis and Design of Integrated Circuits
- ECE 429 Introduction to VLSI Design
- ECE 529 Advanced VLSI Systems Design

Elective Courses in Computer Engineering (1 course minimum)
- ECE 429 Introduction to VLSI Design
- ECE 485 Computer Organization and Design
- ECE 529 Advanced VLSI Systems Design
- ECE 530 High Performance VLSI/IC Systems
- ECE 542 Design and Optimization of Computer Networks
- ECE 545 Advanced Computer Networks
- ECE 583 High Speed Computer Arithmetic
- ECE 584 VLSI Architectures for Signal Processing and Communications
- ECE 585 Advanced Computer Architecture
- ECE 586 Fault Detection in Digital Circuits
- ECE 587 Hardware/Software Co-design
- ECE 588 CAD Techniques for VLSI Design
- ECE 589 Computer Aided-Design of Analog IC

Elective Courses in Electronics (1 course minimum)
- ECE 401 Communication Electronics
- ECE 425 Analysis and Design of Integrated Circuits
- ECE 521 Quantum Electronics
- ECE 524 Advanced Electronic Circuit Design
- ECE 525 RF Integrated Circuit Design
- ECE 526 Active Filter Design
- ECE 527 Performance Analysis of RF Integrated Circuits
- ECE 551 Advanced Power Electronics
- ECE 570 Fiber Optic Communication Systems
- ECE 571 Nanodevices and Technology
- ECE 575 Electron Devices
- ECE 578 Microwave Theory
Master of Telecommunications and Software Engineering

30 credit hours

The Master of Telecommunications and Software Engineering (M.T.S.E.) is a course-only degree program that prepares students for professional practice in telecommunications and information technologies. The program, jointly offered by the Department of Electrical and Computer Engineering (ECE) and Department of Computer Science (CS), can be completed in one year of full-time study. The M.T.S.E. is a professional master’s degree requiring a minimum of 30 credit hours of advisor-approved coursework.

Admission requirements for this degree follow the existing admission requirements for master’s degrees in the ECE department. A person holding a B.S.E.E., a B.S.C.P.E., or a B.S.C.S. degree has the necessary broad background to undertake the M.T.S.E. program. A student without adequate background in specific areas is required to demonstrate proficiency in prerequisite courses: an abbreviated list is given below.

Specific proficiency courses will be detailed for each student at the time of admission to the M.T.S.E. program. A student may demonstrate proficiency by successfully completing the courses or by demonstrating satisfactory performance in one or more special examinations administered by the department.

Computer Science Prerequisites
CS 201 Accelerated Introduction to Computer Science
(i.e., CS 115 and CS 116 combined, Object-Oriented Programming I-II)

Electrical and Computer Engineering Prerequisites
ECE 211 Circuit Analysis I
ECE 213 Circuit Analysis II
ECE 308 Signals and Systems
MATH 251 Multivariate and Vector Calculus
MATH 252 Introduction to Differential Equations
MATH 474 Probability and Statistics

The M.T.S.E. program of studies must include a minimum of 15 credit hours of ECE coursework and a minimum of 12 credit hours of computer science coursework. Five required courses and one elective course from each of the three categories given below must appear on the M.T.S.E. program of studies.

Curriculum

Required Courses
ECE 513 Communication Engineering Fundamentals
CS 586 Software Systems Architecture
CS 587 Software Project Management

One of the following:
ECE 407 Introduction to Computer Networks with Laboratory
ECE 408 Introduction to Computer Networks
ECE 545 Advanced Computer Networks

One of the following:
ECE 541 Performance Evaluation of Computer Networks
ECE 542 Design and Optimization of Computer Networks

Elective Categories
I. Software Engineering
ECE 449 Object-Oriented Programming and Computer Simulation
CS 521 Object-Oriented Analysis and Design
CS 537 Software Metrics
CS 589 Software Testing and Analysis

II. Telecommunication Systems
ECE 443 Introduction to Computer Security
ECE 543 Computer Network Security
ECE 544 Wireless and Mobile Networks
ECE 546 Wireless Network Security
ECE 547 Wireless Network Performance Analysis
CS 544 Computer Networks II: Network Services
CS 548 Broadband Networks
CS 555 Analytic Models and Simulation of Computer Systems

III. Communications
ECE 504 Wireless Communication System Design
ECE 508 Video Communications
ECE 514 Digital Communication Principles
ECE 515 Modern Digital Communications
ECE 519 Coding for Reliable Communications

The remaining nine credit hours of coursework may be taken from courses listed above, or other courses approved by the faculty advisor. Students without a background in communications or software engineering would be best prepared by including:

ECE 403 Digital and Data Communication Systems
ECE 405 Digital and Data Communication Systems with Laboratory
ECE 406 Introduction to Wireless Communication Systems
CS 450 Operating Systems
CS 455 Data Communications
CS 487 Software Engineering I

Other recommended courses include:
ECE 436 Digital Signal Processing I with Laboratory
ECE 437 Digital Signal Processing I
ECE 511 Analysis of Random Signals
ECE 516 Coding for Distributed Storage Systems
ECE 565 Computer Vision and Image Processing
ECE 568 Digital Speech Processing
ECE 569 Digital Signal Processing II
ECE 584 VLSI Architectures for Signal Processing and Communications
CS 588 Advanced Software Engineering Development

With advisor approval, the M.T.S.E. program of studies can include up to four credit hours of ECE short courses.
Master of Electricity Markets

30 credit hours

Restructuring of electricity delivery brings major changes to the electric power industry. Electricity is traded as a commodity in financial markets which affect the way electric power grids are controlled and operated. Today’s electrical engineers are compelled to understand both the technical and business sides of such changes in order to address the needs of the electric power industry.

IIT’s Department of Electrical and Computer Engineering and the Stuart School of Business have teamed up to offer a master’s degree in electricity markets. Combining courses from graduate programs in electrical engineering and in finance, the Master of Electricity Markets degree program provides graduate-level education in electricity suitable for electric power engineers. A background in finance is not required.

The admission requirements for this degree follow the existing admission requirements for other professional master’s degrees in the ECE department. Students whose accredited B.S. degree is not in electrical engineering may pursue this degree, provided that they have an adequate background and can demonstrate proficiency in the material contained in undergraduate courses equivalent to IIT’s: ECE 211 and ECE 213 (Circuit Analysis I and II), ECE 311 (Engineering Electronics), ECE 319 (Fundamentals of Power Engineering), MATH 251 (Multivariate and Vector Calculus), and MATH 252 (Introduction to Differential Equations). A student may demonstrate proficiency by successfully completing the courses or by demonstrating satisfactory performance in one or more special examinations administered by the ECE department.

The program of study includes a minimum of 30 credit hours of acceptable graduate coursework, with a minimum of 15 credit hours from the area of engineering, and a minimum of 6 credit hours from the area of finance. A student can take MSF 502 or MSF 503, but only one can be counted toward the degree program. Six additional credit hours of electives are chosen from graduate coursework in the ECE department.

Curriculum

ECE Courses (minimum of 5)
ECE 417 Power Distribution Engineering
ECE 418 Power Systems Analysis
ECE 419 Power Systems Analysis With Laboratory
ECE 420 Analytical Methods in Power Systems
ECE 553 Power System Planning
ECE 555 Power Market Operations
ECE 556 Power Market Economics and Stability
ECE 557 Fault Tolerant Power Systems
ECE 558 Power System Reliability
ECE 561 Deregulated Power Systems
ECE 562 Power System Transaction Management
ECE 564 Control and Operation of Electric Power Systems
ECE 580 Elements of Sustainable Energy
ECE 581 Elements of Smart Grid
ECE 582 Microgrid Design and Operation

Finance Courses (minimum of 2)
MSF 502 Statistical Analysis in Financial Markets
MSF 503 Financial Modeling
MSF 504 Valuation and Portfolio Management
MSF 505 Futures, Options, and OTC Derivatives
MSF 524 Models for Derivatives
MSF 526 Computational Finance
MSF 534 Corporate Finance
MSF 554 Market Risk Management
MSF 564 Financial Theory
MSF 584 Equity and Equity Derivatives Trading
Energy/Environment/Economics (E³)

32 credit hours

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

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

Master of Electrical and Computer Engineering with (E³) Specialization

32 credit hours

This program has the same requirements as the M.E.C.E. degree program, except that students are required to register for three to six credits of special project research (ECE 594 or ECE 597), plus CHE 543, two courses from the electrical engineering courses listed in Group A, one course from Group B (listed below), and two power and control courses. At least 24 ECE credits are required.

Master of Science in Electrical and Computer Engineering with (E³) Specialization

32 credit hours

Thesis

Candidates for the M.S. in Electrical Engineering are required to take CHE 543 and must select two courses from the electrical engineering courses listed in Group A and one course from Group B (listed below). In addition, students are required to take two power and control courses, and at least one course from each of two minor areas of study: communication theory and signal processing, network electronics and electromagnetics, or computer engineering. The students are also required to register for six to eight credit hours of M.S. thesis research (ECE 591) in an interdisciplinary E³ area and one advanced math course (unless this requirement was met in the B.S. degree). Students may apply up to 12 credit hours of 400-level courses toward the M.S. degree, with their advisor’s approval.

Doctor of Philosophy in Electrical Engineering with (E³) Specialization

84 credit hours

Qualifying exam

Comprehensive exam

Dissertation and oral defense

Students interested in the Ph.D. program in electrical engineering are required to take at least 84 credit hours beyond the B.S. degree requirements, including CHE 543, and at least five E³ courses (from Groups A and/or B). Registration for approximately 32 hours of Ph.D. thesis research in E³ areas of study is also required. Candidates must pass written qualifying and comprehensive examinations and must defend their thesis in an oral examination. The Ph.D. committee for E³ students must include at least one professor with specialization in an energy and sustainability area from outside the student’s department.
E³ Courses
See descriptions under the respective department’s course listings.

Group A

CHE 541
Renewable Energy Technologies

CHE 542
Fluidization and Gas-Solids Flow Systems

CHE 565
Fundamentals of Electrochemistry

CHE 567
Fuel Cell Fundamentals

ECE 550
Power Electronic Dynamics and Control

ECE 551
Advanced Power Electronics

ECE 552
Adjustable Speed Drives

ECE 553
Power System Planning

ECE 554
Power System Relaying

ECE 555
Power Market Operations

ECE 556
Power Market Economics & Security

ECE 557
Fault-Tolerant Power Systems

ECE 558
Power System Reliability

ECE 559
High Voltage Power Transmission

ECE 560
Power Systems Dynamics and Stability

ECE 561
Deregulated Power Systems

ECE 562
Power System Transaction Management

ECE 564
Control and Operation of Electric Power Systems

MMAE 522
Nuclear, Fossil-Fuel, and Sustainable Energy Systems

MMAE 523
Fundamentals of Power Generation

MMAE 524
Fundamentals of Combustion

Group B

EMS 500
Fundamentals of Environmental Science

EM 503
Environmental Pollution Prevention and Control Strategies

EM 504
Industrial Ecology and Systems Thinking

ENVE 501
Environmental Chemistry

ENVE 506
Chemodynamics

ENVE 542
Physiochemical Processes in Environmental Engineering

ENVE 551
Industrial Waste Treatment

ENVE 561
Design of Environmental Engineering Processes

ENVE 570
Air Pollution Meteorology

ENVE 577
Design of Air Pollution Control Devices

ENVE 578
Physical and Chemical Processes for Industrial Gas Cleaning

ENVE 580
Hazardous Waste Engineering
Doctor of Philosophy in Computer Engineering

84 credit hours, including master’s degree studies
Qualifying exam
Comprehensive exam (dissertation proposal defense)
Dissertation
Oral dissertation defense

The doctorate degree in computer engineering is awarded in recognition of mastery in the field of computer engineering and upon demonstrating the ability to make substantial creative contributions to knowledge in that field. The Ph.D. recipient will be capable of making a continuing effort toward the advancement of knowledge and achievement in research and other scholarly activities. This program is appropriate for those students with a master’s degree in computer and/or electrical engineering who are interested in pursuing an academic or industrial research career.

The Ph.D. program requires a minimum of 84 credit hours beyond the bachelor’s degree, including the master’s degree studies. A minimum of 24 credits are devoted to the student’s research work, and a minimum of 24 credits are devoted to coursework in computer and electrical engineering and in basic sciences, such as computers, mathematics, and physics. The selection of courses is considered and approved by the student’s advisor and the department’s graduate program director on the basis of relevance of course content, rather than along a predetermined sequence announced by the department. Generally, it takes a minimum of three years of study beyond the master’s degree to obtain a Ph.D.

Upon admission to graduate study leading to the Ph.D. degree, each student is assigned an academic advisor, who may eventually serve as the thesis advisor and guide the student’s research. The department requires a qualifying examination within the first three semesters of full-time Ph.D. study. This is a written examination covering topics in the area of digital and computer systems and at least one minor area in the field of electrical engineering. This examination is intended to explore both the depth and breadth of the student’s academic abilities.

At an early stage in the student’s research program, and usually about a year after passing the qualifying examination, a comprehensive examination is held in the area of specialization. The comprehensive examination takes the form of a defense of a thesis research proposal. At this time a thesis committee is appointed by the graduate program director, in consultation with the thesis advisor, to guide the remainder of the program. A written dissertation, oral defense, and publication requirement constitute completion of the Ph.D. degree. The defense takes place no earlier than one year after passing the comprehensive examination. Dissertation format and deadlines are established by the Graduate College.

Doctor of Philosophy in Electrical Engineering

84 credit hours, including master’s degree studies
Qualifying exam
Comprehensive exam (dissertation proposal defense)
Dissertation
Oral dissertation defense

The doctorate degree in electrical engineering is awarded in recognition of mastery in the field of electrical engineering and upon demonstration of an ability to make substantial creative contributions to knowledge in that field. The Ph.D. recipient will be capable of a continuing effort toward the advancement of knowledge and achievement in research and other scholarly activities. This program is appropriate for those students with master’s degrees who are interested in pursuing an academic or industrial research career.

The Ph.D. program requires a minimum of 84 credit hours beyond the bachelor’s degree, including the master’s degree studies. A minimum of 24 credits are devoted to the student’s research work, and a minimum of 24 credits are devoted to coursework in electrical and computer engineering and in such basic sciences as mathematics and physics. The selection of courses is considered and approved by the student’s advisor and the department’s graduate program director on the basis of relevance of course content, rather than along a predetermined sequence announced by the department. Work toward the Ph.D. generally takes a minimum of three years of study beyond the master’s degree. Upon admission to graduate study leading to the Ph.D. degree, each student is assigned an academic advisor, who may eventually serve as the thesis advisor and guide the student’s research.

The department requires a qualifying examination within the first three semesters of full-time Ph.D. studies. This is a written examination covering several areas in electrical and computer engineering. This examination is intended to explore both the depth and breadth of the student’s academic abilities. At an early stage in the student’s research program, and usually about a year after passing the qualifying examination, a comprehensive examination is held in the area of specialization. The comprehensive examination takes the form of an oral presentation and defense of a thesis research proposal. At this time a thesis committee is appointed by the graduate program director, in consultation with the thesis advisor, to guide the remainder of the program. A written dissertation, oral defense, and publication requirement constitute completion of the Ph.D. degree. The defense takes place no earlier than one year after passing the comprehensive examination. Dissertation format and deadlines are established by the Graduate College.
Certificate Programs
Certificate programs provide a student with post bac-
calaureate knowledge in an area of specialization within
electrical and computer engineering. Students in these
programs register as certificate non-degree seeking stu-
dents. Certificates are granted upon completion of all
course requirements in the chosen specialization area, as
listed below, with a minimum GPA of 3.0. Certificate
programs must be completed within five years.
It is the student’s responsibility to meet all course pre-
requisites. Any student admitted to a master’s degree
program offered by the department may apply course-
work completed in the certificate program toward the
master’s degree requirements.

Advanced Electronics
This program is composed entirely of elective courses and
provides advanced study in electronic design and device
theory for those who wish to enhance their analog and
digital design skills, while increasing their knowledge of
the underlying device physics. A maximum of two 400
level courses may be taken.

<table>
<thead>
<tr>
<th>Elective Courses (choose four)</th>
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<tbody>
<tr>
<td>ECE 411 Power Electronics</td>
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<tr>
<td>ECE 425 Analysis and Design of Integrated Circuits</td>
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</tbody>
</table>

ECE 521 Quantum Electronics
ECE 524 Advanced Electronic Circuit Design
ECE 525 RF Integrated Circuit Design
ECE 526 Active Filter Design
ECE 527 Performance Analysis of RF Integrated Circuits
ECE 529 Advanced VLSI Systems Design
ECE 530 High Performance VLSI/IC Systems
ECE 571 Nanodevices and Technology
ECE 575 Electron Devices

Applied Electromagnetics
In this certificate program, students receive advanced
preparation for careers in electromagnetic engineering,
particularly in areas of RF circuits and systems, elec-
tromagnetic wave propagation, antenna theory, and
electromagnetic compatibility.

<table>
<thead>
<tr>
<th>Required Courses</th>
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<tbody>
<tr>
<td>ECE 509 Electromagnetic Field Theory</td>
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</table>

AND one of the following:
ECE 421 Microwaves Circuits and Systems
ECE 423 Microwave Circuits and Systems with Laboratory

<table>
<thead>
<tr>
<th>Elective Courses (choose two)</th>
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</thead>
<tbody>
<tr>
<td>ECE 522 Electromagnetic Compatibility</td>
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<tr>
<td>ECE 571 Nanodevices and Technology</td>
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<tr>
<td>ECE 576 Antenna Theory</td>
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<tr>
<td>ECE 578 Microwave Theory</td>
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</tbody>
</table>

Communication Systems
This certificate program is for those who want to be-
come proficient in communication system principles and
applications. The student will take the two fundamental
courses and two courses from a large number of electives,
for emphasis in data compression, computer networks,
and analog/digital communications. No more than one
course may be a 400-level course.

<table>
<thead>
<tr>
<th>Required Courses</th>
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<tbody>
<tr>
<td>ECE 511 Analysis of Random Signals</td>
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<tr>
<td>ECE 513 Communication Engineering Fundamentals</td>
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<table>
<thead>
<tr>
<th>Elective Courses (choose two)</th>
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<tbody>
<tr>
<td>ECE 405 Digital and Data Communication Systems with Laboratory</td>
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<td>ECE 508 Video Communication</td>
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<tr>
<td>ECE 514 Digital Communication Principles</td>
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<tr>
<td>ECE 515 Modern Digital Communications</td>
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<tr>
<td>ECE 516 Coding for Distributed Storage Systems</td>
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<tr>
<td>ECE 519 Coding for Reliable Communications</td>
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<tr>
<td>ECE 541 Performance Evaluation of Computer Networks</td>
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<td>ECE 542 Design and Optimization of Computer Networks</td>
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<tr>
<td>ECE 543 Computer Network Security</td>
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<tr>
<td>ECE 544 Wireless and Mobile Networks</td>
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<tr>
<td>ECE 545 Advanced Computer Networks</td>
</tr>
<tr>
<td>ECE 546 Wireless Network Security</td>
</tr>
<tr>
<td>ECE 547 Wireless Network Performance Analysis</td>
</tr>
</tbody>
</table>
### Computer Engineering

Graduates of this program gain proficiency in one of several areas, including VLSI design, computer networks, computer hardware, and software design. A maximum of one 400-level course may be taken, including ECE 429 if selected as a required course.

#### Required Courses

- ECE 585 Advanced Computer Architecture
- AND one of the following:
  - ECE 429 Introduction to VLSI Design
  - ECE 529 Advanced VLSI Systems Design

#### Elective Courses (choose two)

- ECE 441 Microcomputers
- ECE 443 Introduction to Computer Security
- ECE 446 Advanced Logic Design
- ECE 448 Computer Systems Programming
- ECE 449 Object-Oriented Programming and Computer Simulation
- ECE 485 Computer Organization and Design
- ECE 530 High Performance VLSI/IC Systems
- ECE 541 Performance Evaluation of Computer Networks
- ECE 542 Design and Optimization of Computer Networks
- ECE 543 Computer Network Security
- ECE 544 Wireless and Mobile Networks
- ECE 545 Advanced Computer Networks
- ECE 546 Wireless Network Security
- ECE 547 Wireless Networks Performance Analysis
- ECE 583 High Speed Computer Arithmetic
- ECE 584 VLSI Architectures for Signal Processing and Communications
- ECE 586 Fault Detection in Digital Circuits
- ECE 587 Hardware/Software Codesign
- ECE 588 CAD Techniques for VLSI Design
- ECE 589 Computer-Aided Design of Analog IC

### Control Systems

Engineers who deal with the control and optimization of systems will benefit from the focused coursework in this program, providing intensive studies in linear and non-linear systems, optimized control, controllability and stability of systems, and analysis and synthesis of control systems.

#### Required Courses

- ECE 531 Linear System Theory
- ECE 535 Discrete Time Control Systems

#### Elective Courses (choose two)

- ECE 438 Control Systems
  OR
- ECE 506 Analysis of Nonlinear Systems
- ECE 550 Power Electronic Dynamics and Control

### Electricity Markets

This program is an introduction to both the technical and business sides of a deregulated electric power industry. Students complete two courses from among power system electives and two courses from among finance electives.

#### Power System Courses (choose two)

- ECE 555 Power Market Operations
- ECE 556 Power Market Economics and Security
- ECE 561 Deregulated Power Systems
- ECE 562 Power System Transaction Management

#### Finance Courses (choose two)

- MSF 504 Valuation and Portfolio Management
- MSF 505 Futures, Options and OTC Derivatives
- MSF 554 Market Risk Management
- MSF 584 Equity and Equity Derivatives Trading
Power Electronics

In this certificate program, students receive professional preparation in the areas of power electronic converters, industrial electronics, switching power supplies, electric/electronic motor drives, and electric power quality. This certificate program is useful to managers, engineers, and students who are seeking a position in power electronics related industry.

Required Courses (choose two)

ECE 411 Power Electronics
ECE 550 Power Electronic Dynamics and Control
ECE 551 Advanced Power Electronics
ECE 552 Adjustable Speed Drives

Elective Courses (choose two)

ECE 437 Digital Signal Processing I
ECE 438 Control Systems
ECE 531 Linear System Theory
ECE 535 Discrete Time Systems
ECE 538 Renewable Energies
ECE 539 Computer Aided Design of Electric Machines
ECE 548 Energy Harvesting
ECE 575 Electron Devices

Power Engineering

This program provides power engineers with a solid foundation in the design and analysis of large-scale power systems and state-of-the-art power conversion systems, including power systems control, power electronics, motor drives, design of fault-tolerant systems, power markets, and fundamentals of power system operation and planning.

Core Course (choose one)

ECE 411 Power Electronics
ECE 412 Electric Motor Drives
ECE 418 Power Systems Analysis
ECE 419 Power Systems Analysis with Laboratory
ECE 420 Analytical Methods in Power Systems

Elective Courses (choose three)

ECE 417 Power Distribution Engineering
ECE 538 Renewable Energies
ECE 539 Computer Aided Design of Electric Machines
ECE 540 Reliability Theory and System Implementation
ECE 548 Energy Harvesting
ECE 549 Motion Control Systems Dynamics
ECE 550 Power Electronic Dynamics and Control
ECE 551 Advanced Power Electronics
ECE 552 Adjustable Speed Drives
ECE 553 Power System Planning
ECE 554 Power System Relaying
ECE 555 Power Market Operations
ECE 556 Power Market Economics and Security
ECE 557 Fault-Tolerant Power Systems
ECE 558 Power System Reliability
ECE 559 High-Voltage Power Transmission
ECE 560 Power Systems Dynamics and Stability
ECE 561 Deregulated Power Systems
ECE 562 Power System Transaction Management
ECE 563 Computational Intelligence in Engineering
ECE 564 Control and Operation of Electric Power Systems
ECE 580 Elements of Sustainable Energy
ECE 581 Elements of Smart Grid
ECE 582 Microgrid Design and Operation
Electrical and Computer Engineering

Signal Processing

Those seeking expertise in the areas of signal and image processing should take this program, which offers a wide range of advanced courses in the areas of digital signal processing, data compression, image and speech processing, and pattern recognition.

Required Courses

ECE 511 Analysis of Random Signals
ECE 569 Digital Signal Processing II

Elective Courses (choose two)
(no more than one may be a 400-level course.)
ECE 436 Digital Signal Processing I with Laboratory
ECE 437 Digital Signal Processing I
ECE 481 Image Processing
ECE 507 Imaging Theory and Applications
ECE 508 Video Communications
ECE 565 Computer Vision and Image Processing
ECE 566 Statistical Pattern Recognition
ECE 567 Statistical Signal Processing
ECE 568 Digital Speech Processing
ECE 584 VLSI Architectures for Signal Processing and Communications

Wireless Communication Engineering

For communications engineers who want a focused program providing state-of-the-art instruction in the growing field of wireless communications, this program offers fundamental coursework in traditional telecommunications system design as well as computer communication networks.

Required Courses

ECE 504 Wireless Communication System Design
ECE 513 Communication Engineering Fundamentals

Elective Courses (choose two)
ECE 514 Digital Communication Principles
ECE 515 Modern Digital Communications
ECE 519 Coding For Reliable Communications
ECE 544 Wireless and Mobile Networks
ECE 546 Wireless Network Security
ECE 547 Wireless Networks Performance Analysis
ECE 576 Antenna Theory
Course Descriptions

ECE 502  
**Basic Network Theory**  
(3-0-3)

ECE 504  
**Wireless Communication System Design**  
Fundamentals of first (1G), second (2G), third (3G), and future generation cellular communication systems. This course covers the transition from 1G to 3G systems. Topics included are speech and channel encoders, interleaving, encryption, equalization, modulation formats, multi-user detection, smart antennas, technologies that are used in these transitions, and future generations of cellular systems. Compatibility aspects of digital cellular systems are discussed along with a review of the standards for the industry. TDMA and CDMA systems are covered in detail.  
Prerequisite(s): [(ECE 511)]  
(3-0-3)

ECE 505  
**Applied Optimization for Engineers**  
Principles of optimization for practical engineering problems, linear programming, nonlinear unconstrained optimization, nonlinear constrained optimization, dynamic programming.  
(3-0-3)

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

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

ECE 508  
**Video Communications**  
This course covers the fundamentals of video coding and communications. The principles of source coding for the efficient storage and transmission of digital video will be covered. State-of-the-art video coding standards and error-resilient video coding techniques will be introduced. Recent technologies for robust transmission of video data over wired/wireless networks will be discussed. A detailed overview of architectural requirements for supporting video communications will be presented. Error control and cross-layer optimization techniques for wireless video communications will be covered.  
Prerequisite(s): [(ECE 437 and ECE 511)]  
(3-0-3)

ECE 509  
**Electromagnetic Field Theory**  
Electric and magnetic fields produced by charge and current distributions. Solution of Laplace’s and Poisson’s equations, time-varying fields and electromagnetic waves. Applications to waveguides and antennas.  
Prerequisite(s): [(ECE 307)]  
(3-0-3)

ECE 511  
**Analysis of Random Signals**  
Probability theory, including discrete and continuous random variables, functions and transformations of random variables. Random processes, including correlation and spectral analysis, the Gaussian process and the response of linear systems to random processes.  
Prerequisite(s): [(ECE 308 and MATH 474)]  
(3-0-3)

ECE 513  
**Communication Engineering Fundamentals**  
Review of probability and random processes. AM with noise, FM with noise. Introduction to digital communication. Source coding, signal space analysis, channel modulations, optimum receiver design, channel encoding.  
Prerequisite(s): [(ECE 403 and MATH 474)]  
(3-0-3)

ECE 514  
**Digital Communication Principles**  
Information transmission fundamentals, including capacity, entropy, Shannon’s theorems and source coding. Introduction to rate distortion theory. Advanced digital modulation and demodulation techniques, performance measures. Channel coding and introduction to trellis coded modulation.  
Prerequisite(s): [(ECE 511 and ECE 513)]  
(3-0-3)

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

ECE 516  
**Coding for Distributed Storage Systems**  
Distributed storage systems, such as data centers, are becoming a vital infrastructure of today’s society by allowing to store reliably large amounts of data and make it accessible anywhere and anytime. The goal of this course is to train students with the different mathematical and engineering tools that are needed when studying and designing codes and algorithms for data reliability and security in these large-scale systems. The course will cover relevant topics in information theory, coding theory, graph theory, and wireless communications in addition to the active on-going research in this area.  
Prerequisite(s): [(ECE 511)]  
(3-0-3)
ECE 519
Coding for Reliable Communications
Encoders and decoders for reliable transmission of digital data over noisy channels. Linear block codes, cyclic codes, BCH codes, convolutional codes. Burst error correcting codes. Maximum likelihood decoding of convolutional codes. Performance of block and convolutional codes in additive white Gaussian channel.
Prerequisite(s): [ECE 438] (3-0-3)

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

ECE 521
Quantum Electronics
Prerequisite(s): [ECE 307] (3-0-3)

ECE 522
Electromagnetic Compatibility
Prerequisite(s): [ECE 307] (3-0-3)

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

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

ECE 526
Active Filter Design
Analysis and design of linear active filters with emphasis on realizations using operational amplifiers. Sensitivity analysis. Switched capacitor filters.
Prerequisite(s): [ECE 308 and ECE 312] (3-0-3)

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

ECE 529
Advanced VLSI Systems Design
Advanced design and applications in VLSI systems. The topics of this course include design tools and techniques, clocking issues, complexity management, layout and floor planning, array structures, testing and testability, advanced arithmetic circuitry, transcendental function approximations, architectural issues, signal processing architecture and submicron design. Design projects are completed and fabricated by student teams.
Prerequisite(s): [ECE 429] (3-0-3)

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

ECE 531
Linear System Theory
Prerequisite(s): [ECE 308] (3-0-3)

ECE 535
Discrete Time Systems
Prerequisite(s): [ECE 438] (3-0-3)
ECE 538
Renewable Energies
Various renewable energy sources such as solar systems, wind powered systems, ocean tides, ocean waves, and ocean thermal are presented. Their operational principles are addressed. Grid connected interfaces for such systems are explained. Research and Simulation mini-projects with emphasis on either machine design, or power electronic circuit analysis, design, and controls, or grid connected renewable systems are assigned to student groups. 
Prerequisite(s): [(ECE 311)]
(3-0-3)

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

ECE 540
Reliability Theory & System Implementation
Basic probability and modeling techniques on component, subsystem and system levels. MTBF, MTTR and downtime. Hardware, software and cost considerations. Switching systems. Multicomputer and memory configurations.
Prerequisite(s): [(ECE 308 and MATH 474)]
(3-0-3)

ECE 541
Performance Evaluation of Computer Networks
Introduction to performance evaluation techniques for computer and communication networks. Little's theorem, birth-death processes, M/G/1 queue, product from queuing networks, approximation techniques for G/G/1 queues and non-product form queuing networks. Discrete event simulations, generation of random variables, variance reduction techniques and general purpose simulation languages.
Prerequisite(s): [(ECE 407 and MATH 474)]
(3-0-3)

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

ECE 543
Computer Network Security
This course introduces network security by covering topics such as network-related security threats and solutions, private- and public-key encryptions, authentication, digital signatures, Internet Protocol security architecture (IPSEC), firewalls, network management, email and web security.
Prerequisite(s): [(ECE 407) OR (ECE 408)]
(3-0-3)

ECE 544
Wireless & Mobile Networks
This course provides an overview of different wireless and mobile network standards and systems. The topics covered include cellular networks, satellite networks, wireless local area networks, wireless personal area networks, mobile IP, ad hoc networks, sensor networks, wireless mesh networks and wireless network security.
Prerequisite(s): [(ECE 407) OR (ECE 408)]
(3-0-3)

ECE 545
Advanced Computer Networks
Fundamentals of computer communication networks. Overview of data communication networks and protocol architectures with emphasis on the Internet protocols and network elements. Principles of network and protocol design; error detection and correction, flow control and congestion control, delay and throughput models, QoS, service support and application interface (including remote procedure call mechanisms). Local and Wide Area Networks (Ethernet, FDDI, Wireless LAN, ATM and Internet). LAN and Wan interconnection using bridges, routers, switchers and gateways. Routing in data networks. Network and protocol design to support multimedia and multicasting connections.
Network application security.
Prerequisite(s): [(ECE 407) OR (ECE 408)]
(3-0-3)

ECE 546
Wireless Network Security
This course focuses on selected research topics current interest in wireless network security. This course will cover security and privacy issues in wireless systems, including cellular networks, wireless LAN, mobile ad hoc networks (MANET), wireless mesh networks, sensor networks, vehicular networks, RFID, and ubiquitous computing.
Prerequisite(s): [(ECE 543)]
(3-0-3)

ECE 547
Wireless Networks Performance Analysis
This course deals with the performance analysis techniques for the main types of wireless networks used today including cellular communication networks, wireless local area networks (WLAN), zigbee wireless networks, and wireless mesh networks. The course not only discusses the details of the related IEEE standards but also focuses on mathematical modeling and analysis to compute the quality of service metrics as well as resource utilization efficiency. Key topics include cellular system design, mobility management, conflict-free medium access, contention-based medium access, Markov chain modeling for 802.11, fixed-point based analysis, 802.15.4 modeling and analysis, and wireless mesh network capacity analysis.
Prerequisite(s): [(ECE 544)]
(3-0-3)

ECE 548
Energy Harvesting
Various harvesting techniques such as solar, ocean ides, vibration, linear motion, radio frequency, passive and active human power generation are presented. Their operational principles are addressed. Research and simulations mini-projects with emphasis on power electronic circuit analysis, design, and controls are assigned to student groups.
Prerequisite(s): [(ECE 311)]
(3-0-3)
ECE 549
Motion Control Systems Dynamics
Fundamentals and applications of motion control systems, control techniques for high precision motion control, state variable feedback of linear and nonlinear systems, multivariable systems, physical system modeling, graphical analysis, and numerical analysis, and system performance analysis. Prerequisite(s): [(ECE 438)]
(3-0-3)

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

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

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

ECE 553
Power System Planning
Model development. Interchange capability, interconnections, pooling, Economic generator size and site selection. Concept of reserves, transformers, relays and circuit breakers. Reactive planning AC and DC systems are explored thoroughly from a planning standpoint. Prerequisite(s): [(ECE 418) OR (ECE 419)]
(3-0-3)

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

ECE 555
Power Market Operations
Market Design in Restructured Power Systems, Short-term Load Forecasting, Electricity Price Forecasting, Price Based Unit Commitment, Arbitrage in Electricity Market, Market Power Analysis, Asset Valuation and Risk Analysis, Security Constrained Unit Commitment, Ancillary Services Auction Market Design, Power Transmission Pricing, Regional Transmission Organizations. Prerequisite(s): [(ECE 418) OR (ECE 419)]
(3-0-3)

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

ECE 557
Fault-Tolerant Power Systems
(3-0-3)

ECE 558
Power System Reliability
The concept of reliability, reliability indices, component reliability, generation capacity reserve evaluation, transmission system reliability, bulk power system reliability, distributed system reliability, reliability modeling in context. Prerequisite(s): [(ECE 418) OR (ECE 419)]
(3-0-3)

ECE 559
High Voltage Power Transmission
Detailed analysis of transmission and distribution systems. Design of high voltage transmission lines and cables, as well as distribution lines. Flexible AC transmission Systems (FACTS) and high voltage DC links. Prerequisite(s): [(ECE 418) OR (ECE 419)]
(3-0-3)

ECE 560
Power Systems Dynamics & Stability
The transient stability problem, acceleration equations, stability criteria, two-machine and multimachine problems. Perturbation analysis, eigenvalue sensitivity, Lyapunov theory and application to power systems stability. Prerequisite(s): [(ECE 418) OR (ECE 419)]
(3-0-3)
ECE 561
Deregulated Power Systems
Overview of key issues in electric utilities restructuring, Poolco model, bilateral contracts, market power, stranded costs, transmission pricing, electric utility markets in the United States and abroad, OASIS, tagging electricity transactions, electric energy trading, risk in electricity markets, hedging tools for managing risks, electricity pricing, volatility in power markets, and RTO.
Prerequisite(s): [ECE 418] OR [ECE 419] (3-0-3)

ECE 562
Power System Transaction Management
Power interchange transaction management in the deregulated electric power industry. Course topics include: power system security assessment, total and available transfer capability (TTC/ATC), transaction management system (TMS), transaction information system (TIS), tagging calculator (IDC), congestion management, transmission loading relief (TLR).
Prerequisite(s): [ECE 418] OR [ECE 419] (3-0-3)

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

ECE 564
Control & Operation of Electric Power Systems
Unit commitment and application of dynamic programming, fuel budgeting and planning, probabilistic production cost modeling, hydrothermal coordination, power system security and application of expert systems, state estimation, optimal power flow, interchange evaluation and power pools, reactive power planning.
Prerequisite(s): [ECE 418] OR [ECE 419] (3-0-3)

ECE 565
Computer Vision & Image Processing
Multidimensional sampling and discrete Fourier transform; Image segmentation; Object boundary (edge) detection and description; shape representation and extraction; Matching and recognition; Camera geometry and stereo imaging; Morphological processing; Motion detection and compensation; Image modeling and transforms; Inverse problems in image processing (restoration and reconstruction).
Prerequisite(s): [ECE 437] AND [ECE 419] (3-0-3)

ECE 566
Statistical Pattern Recognition
Prerequisite(s): [ECE 511] (3-0-3)

ECE 567
Statistical Signal Processing
Prerequisite(s): [ECE 511 and MATH 333] (3-0-3)

ECE 568
Digital Speech Processing
Prerequisite(s): [ECE 437 and ECE 511] (3-0-3)

ECE 569
Digital Signal Processing II
Prerequisite(s): [ECE 437 and MATH 474] (3-0-3)

ECE 570
Fiber-Optic Communication Systems
Prerequisite(s): [ECE 307 and ECE 312] AND [ECE 403] (3-0-3)

ECE 571
Nanodevices & Technology
(3-0-3)

ECE 575
Electron Devices
Prerequisite(s): [ECE 307 and ECE 312] (3-0-3)
ECE 576
Antenna Theory
Plane and spherical waves. Electric and magnetic dipoles. Radiation patterns and impedance characteristics of antennas in free space and over perfect ground. Linear and planar driven antenna arrays. Yagi-Uda parasitic arrays. Prerequisite(s): [(ECE 307) OR (ECE 421) OR (ECE 423)] (3-0-3)

ECE 578
Microwave Theory
Microwave field theory. Propagation, reflection and refraction of plane waves. Anisotropic media. Impedance concept. Hollow, surface-wave and dielectric wave guides. Discontinuities in wave guides. Microwave resonators. Transmission lines. Microwave circuit theory. Prerequisite(s): [(ECE 421) OR (ECE 423)] (3-0-3)

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

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

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

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

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

ECE 585
Advanced Computer Architecture
Design, Analysis and Performance of High-Performance Computer Architectures; High Speed memory Systems: Cache Design and Analysis; Modeling Cache Performance; Instruction Level Parallelism, Cache-only Memory Architectures, Classification of Parallel Architectures; Systolic and Data Flow Architectures; Multiprocessor Performance; and Multiprocessor Iterations. (3-0-3)

ECE 586
Fault Detection in Digital Circuits
Essential elements in testing and testability of digital designs. Automatic tests generation algorithms and fault-simulation methods. Design methodologies to increase testability and decrease test generation costs. Techniques for built-in testing. Prerequisite(s): [(ECE 446)] (3-0-3)

ECE 587
Hardware/Software Codesign
Computer-aided techniques for the joint design of hardware and software: specification, analysis, simulation and synthesis. Hardware/software partitioning, distributed system cosynthesis, application-specific instruction set design, interface cosynthesis, timing analysis for real-time systems. Prerequisite(s): [(CS 201 and ECE 441)] (3-0-3)
ECE 588  
CAD Techniques for VLSI Design  
Overview of techniques and algorithms used in Computer-Aided Design (CAD) for VLSI circuits. Physical CAD tools, including placement, routing, symbolic layout and compaction. High-level CAD tools, including logic synthesis, silicon compilers and high-level synthesis. Recent developments in the field. Design, implementation and performance analysis of prototype CAD tools.  
Prerequisite(s): [(ECE 429)]  
(3-0-3)

ECE 589  
Computer-Aided Design of Analog IC  
Analog IC design optimization algorithm such as equation-based optimization and simulation-based optimization algorithms, design automation tools such as harmonic balance, projection-based surface response estimation, shooting methods, etc. will be introduced. Research and mini-projects with emphasis on analog integrated circuit design and optimization algorithms using state-of-the-art tools are assigned to student groups.  
Prerequisite(s): [(ECE 513)]  
(2-0-2)

ECE 591  
Research & Thesis for Masters Degree  
(Credit: Variable)

ECE 593  
Masters Electrical & Computer Engineering Seminar  
Seminar course for Master students.  
(1-0-0)

ECE 594  
Special Projects  
Special projects.  
(Credit: Variable)

ECE 597  
Special Problems  
Special problems.  
(Credit: Variable)

ECE 600  
Continuation of Residence  
Continuation of residence.  
(0-0-1)

ECE 691  
Research & Thesis for Ph.D.  
Research & Thesis for Ph.D.  
(Credit: Variable)

ECE 693  
Doctoral Electrical & Computer Engineering Seminar  
Seminar course for Ph. D. students.  
(1-0-0)

ECE 708  
Technologies for Long-Term Evolution of Wireless Communications Networks  
The course discusses technologies used in long-term evolution (LTE) wireless communications systems. Fundamentals of multiple-input/multiple-output (MIMO) wireless communication systems and orthogonal frequency division modulation (OFDM) are covered. Transmission diversity concepts and principles of space-time coding are introduced. The fundamentals of space-time block and trellis coded modulation (STBC and STTCM) are introduced along with performance analysis, code design, and simulation results. A comparison of various design techniques in different propagation environments is presented. Applications to MIMO/OFDM systems are discussed.  
Prerequisite(s): [(ECE 513)]  
(2-0-2)

ECE 719  
Theory & Applications of Linear Optimization in Wireless Networks  
This short course covers both the fundamental of linear optimization and applications in wireless networking research, emphasizing not only the optimization methodology but also the underlying mathematical structures. In addition to the fundamental contents of simplex method, duality theory, and network flow problems, this course also covers the integer programming techniques. This course discusses the applications of linear optimization in the wireless network, including wireless mesh networks, multi-radio multi-channel networks, and cognitive radio networks.  
Prerequisite(s): [(ECE 407) OR (ECE 408)] AND [(MATH 477)]  
(2-0-2)

ECE 721  
Introduction to Wireless Cooperative Communications & Applications  
The course gives an introduction to wireless cooperative communication networks from the perspective of the channel and physical layer. It discusses cooperative networks protocols and application of these. It will deal with wireless channels and relay networks. Transparent and regenerative physical layer algorithms will be discussed to facilitate the analysis of different architectures. Use of distributed space time codes, multiplexing, and orthogonal frequency division multiplexing will be analyzed to achieve multi-dimensional diversity (path, frequency, and time), reduced interference, and improved QoS.  
Prerequisite(s): [(ECE 403)]  
(2-0-2)
ECE 735
Cellular Long Term Evolution
Cellular Long Term Evolution (LTE) is a key wireless broadband technology considered as the primary path towards the next generation networks (NGNs). It is generally considered as the dominant wireless technology meeting the seamless, mobile Internet access needs of the upcoming Quadruple Play applications. This short course covers the applications, requirements, architecture, radios and antennas, protocols, network operations and management, and evolution for the LTE technology. Key topics include the functions and interfaces of the protocol layers, Quality of Service (QoS), security, network signaling, infrastructure, user equipment, spectrum, throughput, and coverage. Discussion includes the modulation schemes, frame structure, antenna and radio, and subcarrier and bandwidth allocation methods. End-to-end scenarios on connection setup, interworking with existing 3G cellular, WiFi, and WiMAX networks, and handovers are discussed. Testing and integration issues, limitations, and challenges are also mentioned. Comparative analysis with respect to WiMAX and ultra mobile broadband (UMB) are covered. The likely migration paths from current wireless and wireline networks to LTE and related HSOPA and SAE architectures are discussed.

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

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

ECE 740
Telecommunication Networks: Requirements to Deployment
The ever-increasing customer demand for new and advanced services and the associated complexities of designing, deploying, optimizing, and managing telecom networks require advanced end-to-end technology and process expertise. This short course deals with the key concepts of requirements development, design processes, architecture finalization, system design, site testing, performance optimization, and network operations and management of current and upcoming Telecom networks. It provides an overview on how the process works from an idea or concept to productization and will give a view on associated complexities and challenges. Key advances in tools and techniques needed with these major steps are covered. Practical examples of the current and upcoming features which will make telecom networks competitive are addressed. Aspects of customer management, strategies for decision making, and the migration towards future networks are also addressed. Practical examples of networks of selected service providers and how they meet the local and global needs are mentioned.

ECE 742
Digital System-on-Chip Design
This short course covers digital design techniques and hardware/software realization concepts in embedded computing systems using VHDL. Topics include: basics principles of VHDL programming; designing with FPGA; design of arithmetic logic unit; VHDL models for memories and busses; CPU design; system-on-chip design; efficient hardware realizations of FFT, DCT, and DWT.

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

ECE 744
Embedded Digital Systems for Time-Frequency Distribution, Signal Modeling, & Estimation
This short course deals with time-frequency distribution, signal modeling and estimation, and hardware/software realization concepts in embedded computing systems. Key topics include fundamentals of signal processing and random processes, short-time Fourier transform, split-spectrum processing, Gabor transform, Wigner distribution, Hilbert transform, wavelet transform, cosine transform, chirplet signal decomposition, matching pursuit, parametric time-series frequency estimation, hardware/software codesign and realizations of time-frequency distributions, and signal modeling algorithms.
ECE 750
Synchrophasors for Power System Monitoring & Control
The course gives an introduction to synchrophasor technology from the perspective of power system monitoring and control. It discusses the fundamentals of measurements and synchrophasor estimation. It covers the IEEE Standard C37.118. Several synchrophasor estimation algorithms will be discussed as they relate to measurement and estimation errors. Various synchrophasor applications will be presented including situational awareness, event detection, model validation, oscillation detection, WAMS, and WAMPAC.
Prerequisite(s): [(ECE 419)]
(2-0-2)

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

ECE 755
Power System Protection
This course provides basic understanding of the role of protective relaying in the power system. It also delves into the needs of today’s power systems for protection that is robust and tolerant to heavily loaded transmission systems. The students are challenged to be a part of the solution going forward including the role of wide area system protection.
(2-0-2)

ECE 756
Power System Maintenance Scheduling
This short course is aimed at providing an in-depth introduction to optimal generation and transmission maintenance in the regulated and restructured power systems. The basic principles of systems operation and economics related to maintenance scheduling will be discussed along with current practices and solution methods for the electric power industry.
Prerequisite(s): [(ECE 419 and ECE 420)]
(2-0-2)

ECE 764
Vehicular Power Systems
Conventional electrical power systems of land, sea, air, and space vehicles are detailed along with the scope for improvement. New electrical loads and advanced distribution system architectures of electric and hybrid electric vehicles are presented. Current trends in the vehicular industry, such as 42V automotive systems and more electric aircraft, are explained.
(2-0-2)

Undergraduate Courses Available to Graduate Students
Note: Students may take up to an approved number of the following courses.

ECE 401
Communication Electronics
ECE 403
Digital and Data Communication Systems
ECE 405
Digital and Data Communication Systems with Laboratory
ECE 407
Introduction to Computer Networks with Laboratory
ECE 408
Introduction to Computer Networks with Laboratory
ECE 411
Power Electronics
ECE 412
Power Electronics
ECE 417
Power Distribution Engineering
ECE 418
Power Distribution Engineering
ECE 419
Power Distribution Engineering
ECE 420
Power Distribution Engineering
ECE 421
Power Distribution Engineering
ECE 423
Microwave Circuits and Systems with Laboratory
ECE 425
Analysis and Design of Integrated Circuits
ECE 429
Introduction to VLSI Design
ECE 436
Digital Signal Processing I with Laboratory
ECE 437
Digital Signal Processing I with Laboratory
ECE 438
Digital Signal Processing I with Laboratory
ECE 441
Microcomputers
ECE 446
Advanced Logic Design
ECE 449
Object-Oriented Programming and Computer Simulation
ECE 481
Image Processing
ECE 485
Computer Organization and Design