Department of Electrical and Computer Engineering

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Department Chair:
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Graduate Program Director:
Jafar Saniie

The Department of Electrical and Computer Engineering offers academic programs in advanced study to graduates with technical background 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 background 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 the 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 over 50 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 Electrical and Computer Engineering
Master of Biomedical Imaging and Signals
Master of Power Engineering
Master of VLSI and Microelectronics
Master of Network Engineering
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 Center for Financial Markets:
Master of Electricity Markets

Certificate Programs

Advanced Electronics
Applied Electromagnetics
Communication Systems
Computer Engineering
Control Systems
Electricity Markets
Power Electronics
Power Engineering
Signal Processing
Wireless Communications Engineering

Interdisciplinary Programs

Master of Science in Electrical Engineering with specialization in energy/environment/economics (E^3)
Master of Manufacturing Engineering
Master of Science in Manufacturing Engineering

Research Centers and Facilities

The department operates research laboratories for work in CAD for VLSI and SoC design, communications, computer networking, embedded computing, image processing and medical imaging, microwave electronics, power systems, 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 department also collaborates with and utilizes the research resources of the Pritzker Institute of Biomedical Science and Engineering and nearby national laboratories.

Research Centers and Facilities continued

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, running the Unix/Linux 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, 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, 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 communication systems; computer systems and VLSI; electromagnetics and electronics; power and control systems; signal and image processing.

Faculty

Tricha Anjali, Assistant Professor. M. Tech. in Electrical Engineering, Indian Institute of Technology; Ph.D., Georgia Institute of Technology. Broadband networks, adaptive network management and optical networks.

Robert Arzbacher, Emeritus Professor. Ph.D., University of Illinois, Urbana-Champaign, Instrumentation, signal procesing and control.

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

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

Jovan G. Brankov, Research Assistant Professor. Dipl. Ing., Electrical Engineering, University of Belgrade; M.Sc., Ph.D., Illinois Institute of Technology. Medical imaging, image sequence processing, pattern recognition and data mining.

Yu Cheng, Assistant Professor. B.E. and M.E., Tsinghua University (China); Ph.D. the University of Waterloo (Canada), Computer network management, Internet measurement, performance analysis, and quality of service provisioning, wireless networks, and wireless/wireline interworking.

Ali Emadi, Professor, B.S., M.S., Sharif University of Technology (Iran); Ph.D., Texas A&M University. Power electronics, motor drives, electric machines, vehicular power systems.

Alexander J. Flueck, Associate Professor. B.S., M.E., Ph.D., Cornell University. Power systems, computational methods, control systems.

Zuyi Li, Assistant Professor. B.S. (EE), Shanghai Jiaotong University (China); M.S., Tsinghua University (China); Ph.D., Illinois Institute of Technology. Market operation of electric power system, security-constrained unit commitment, arbitrage in electricity market, market power analysis and risk management, ancillary services auction, transmission pricing.

Joseph L. LoCicero, Professor. B.E.E., M.E.E., City College of New York; Ph.D., City University of New York. Communication and digital signal processing, speech and image processing, discrete multitone communications, automatic speech recognition, ultra-wideband communications.

Erdal Oruklu, Assistant Professor. 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.

Gerald F. Saletta, EmeritusProfessor. B.S., M.S., University of Notre Dame; Ph.D., Illinois Institute of Technology. Electronics, digital systems.

Jafar Saniie, Professor, Graduate Program Director, and Computer Engineering Director. 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.

Marco Saraniti, Associate Professor. B.A., University of Modena (Italy); Ph.D., Techniche University Munich (Germany) Computational electronics and numerical methods applied to particle-based 2-D and 3-D physical simulation of semiconductor devices.

Mohammad Shahidehpour, Carl and Paul Bodine Professor, and Department Chair. 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.

Henry Stark, Motorola Professor. B.E.E., City College of New York; M.S., D.Eng.Sc., Columbia University. Image reconstruction, medical imaging, pattern recognition, signal processing and sampling theory, optics.

Donald R. Ucci, Associate Professor and Associate Provost. B.E., M.E., Ph.M., City College of New York; Ph.D., City University of New York. Adaptive systems, signal processing, communications, stochastic processes.

Dimitrios Velenis, Assistant Professor. B.S., Technical University of Crete (Greece), M.S., Ph.D. University of Rochester. Noise tolerant clock distribution network, VLSI.

Faculty continued

Albert Z. Wang, Associate Professor. B.E., Tsinghua University (China); M.S., The Chinese Academy of Sciences (China); Ph.D., State University of New York at Buffalo. Analog/Mixed-Signal/RF/low-power integrated circuits, IC reliability engineering, VLSI CAD, semiconductor devices and modeling.

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

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

Geoffrey Williamson, Professor. B.S., M.S., Ph.D., Cornell University. Adaptive filtering, signal processing and control, parameter estimation and system identification, control systems, robust control theory.

Thomas T. Y. Wong, Professor. B.S., University of Hong Kong; M.S., Ph.D., Northwestern University. Microwave communications systems, nonlinear device measurement, semiconductor device theory, microwave electronics and instrumentation.

Yongyi Yang, Associate Professor. B.S., M.S., Northern Jiatong University (China); M.S., Ph.D., Illinois Institute of Technology. Image and signal processing, data compression, applied mathematical and statistical methods.

Imam Samil Yetik, Assistant Professor. B.S., Bogazici University (Turkey), M.S., Bilkent University (Turkey), Ph.D., University of Illinois at Chicago, Statistical signal and image processing with applications to biomedicine.

Chi Zhou, Assistant Professor. B.S., Tsinghua University (China), M.S. and Ph.D., Northwestern University, Resource allocation and power control for multimedia cellular networks, integration of 3G, WLAN, WiMAX and SONET, sensor networks, jamming avoidance over OFDM or MIMO systems.

Admission Requirements

Cumulative undergraduate GPA minimum: 3.0/4.0
GRE minimum score:
For tests taken prior to Oct.1, 2002, M.S./MAS/Ph.D.: 1500 (combined)
For tests taken on or after Oct.1, 2002, M.S./MAS: 1100 (quantitative + verbal) 3.5 (analytical writing)
For tests taken on or after Oct.1, 2002 Ph.D.: 1100 (quantitative + verbal) 3.5 (analytical writing)
TOEFL minimum score: 550/213*

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, 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 adviser 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.

Master of Science in Electrical Engineering

32 credit hours
Thesis option

The purpose of this degree is to prepare students for advanced study and/or research 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 adviser. Areas of study include communication and signal processing; electronics and electromagnetics; power and control systems; and computer engineering. The program is normally completed in three semesters of full-time study.

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 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 20 credit hours of ECE courses at the 500-level or higher, excluding masters seminars. Up to two credits of Master's Seminar (ECE 595 or ECE 596) and up to six credits of ECE short courses may be applied to the degree. Students, with their adviser, select courses appropriate to their needs and interests.

The program of study must include four courses within one of the electrical engineering (EE) areas of concentration listed below and one course from two of the remaining three areas. (For example, a student might elect to take four courses in communication theory and signal processing; one course in networks, electronics and electromagnetics; and one course in computer engineering.) Courses listed in more than one area (e.g., ECE 545) may be applied to only one area to fulfill the academic requirements.

One advanced mathematics course is also required (unless such a course was completed in the student's undergraduate program). Acceptable courses include ECE 505 (Applied Optimization for Engineers); any 400- or 500-level mathematics course, excluding MATH 474 (Probability and Statistics), MATH 475 (Probability), ECE 475 (Random Phenomena in Electrical Engineering), MATH 490 (History of Mathematics), and any variable-credit course; CHE 536 (Computational Techniques in Engineering); MMAE 504 (Engineering Analysis Ia); MMAE 501 (Engineering Analysis Ib); MMAE 502 (Engineering Analysis II); MMAE 503 (Advanced Engineering Analysis); MMAE 505 (Numerical Methods in Engineering); MMAE 506 (Computational Methods in Engineering Analysis); and MMAE 508 (Perturbation Methods).

An M.S.E.E. candidate may, with permission of a thesis adviser, 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. Communication Theory and Signal Processing

ECE 401 Communication Electronics
ECE 403 Communication Systems
ECE 404 Digital and Data Communications
ECE 406 Digital and Data Communications with Laboratory
ECE 407 Introduction to Computer Networks
ECE 409 Communication Electronics 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 508 Signal and Data Compression
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
ECE 545 Advanced Computer Networks
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 584 VLSI Architectures for Signal Processing and Communications

II. Electronics and Electromagnetics

ECE 401 Communication Electronics
ECE 409 Communication Electronics with Laboratory
ECE 411 Power Electronics
ECE 414 Audio and Electroacoustics
ECE 415 Solid-State Electronics
ECE 421 Microwave Circuits and Systems
ECE 423 Microwave Circuits and Systems with Laboratory
ECE 425 Analysis and Design of Integrated Circuits
ECE 429 Introduction to VLSI Design
ECE 470 Photonics
ECE 471 Photonics with Laboratory
ECE 502 Basic Network Theory
ECE 509 Electromagnetic Field Theory
ECE 521 Quantum Electronics
ECE 522 Electromagnetic Compatibility
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 550 Power Electronic Dynamics and Control
ECE 551 Advanced Power Electronics
ECE 570 Fiber Optic Communication Systems
ECE 571 Nanodevices and Technology
ECE 575 Electron Devices
ECE 576 Antenna Theory
ECE 577 Advanced Antenna Theory
ECE 578 Microwave Theory
ECE 579 Numerical Methods in Electromagnetics and Solid-State Electronics

III. Power and Control Systems

ECE 411 Power Electronics
ECE 412 Electric Motor Drives
ECE 419 Power Systems Analysis
ECE 420 Analytical Methods in Power Systems
ECE 434 Control Systems with Laboratory
ECE 438 Control Systems
ECE 506 Analysis of Nonlinear Systems
ECE 531 Linear System Theory
ECE 535 Discrete Time Systems
ECE 537 Optimal Feedback Control
ECE 540 Reliability Theory and System Implementation
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 Systems 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

IV. Computer Engineering

ECE 407 Introduction to Computer Networks
ECE 425 Analysis and Design of Integrated Circuits
ECE 429 Introduction to VLSI Design
ECE 441 Microcomputers
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 529 Advanced VLSI Systems Design
ECE 530 High Performance VLSI/IC Systems
ECE 541 Performance Evaluations of Computer Networks
ECE 542 Design and Optimization of Computer Networks
ECE 543 Computer Network Security
ECE 545 Advanced Computer Networks
ECE 565 Computer Vision and Image Processing
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

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 and industry 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 adviser. 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. 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), 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 excluding short courses and Master's Seminar. Up to two credits of master's seminar (ECE 595 or ECE 596), and up to six credits of ECE short courses may be applied to the degree. Students, in consultation with their adviser, 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 adviser, 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 and Curriculum

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 441	Microcomputers
ECE 446	Advanced Logic Design
ECE 485	Computer Organization and 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

Computer Systems Software

Core courses

CS 550	Comparative Operating Systems
CS 551	Operating System Design and Implementation

Elective courses

ECE 448	Computer Systems Programming
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 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

Networks and Telecommunications

Core courses

ECE 407	Introduction to Computer Networks AND/OR
ECE 545	Advanced Computer Networks
AND	
ECE 541	Performance Evaluation of Computer Networks
AND/OR	
ECE 542	Design and Optimization of Computer Networks

Elective courses

ECE 504	Wireless Communication System Design
ECE 508	Signal and Data Compression
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 543	Computer Network Security
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 field 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 adviser.

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 normally completed in four semesters of full-time study.

Admission requirements for the CPE/EE 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 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), 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:

   Two core courses in a CPE major area, chosen from among the CPE areas of concentration.

   Two elective courses in the CPE major area, chosen from among the CPE areas of concentration.

   One core course from each of two remaining areas of CPE concentration.

   Four (or more) courses within an EE major area, chosen from among the EE areas of concentration (Areas I, II and III).

   One (or more) course(s) in each of two EE minor areas, chosen from among the Areas I, II and III outside the major.

   One advanced mathematics course required for EE major area unless included in the B.S. degree.

   Additional coursework approved by the academic adviser

The CPE/EE Program is subject to the following restrictions: a minimum of 30 credit hours of coursework at the 500-level or higher; at least 30 credit hours of ECE courses excluding short courses and Master's Seminars; 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 adviser; and a maximum of two credits of a Master's Seminar (ECE 595 and ECE 596)

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

Courses classified in two areas may be applied to only one area to fulfill requirements. Intersession short courses may not be used to satisfy distribution requirements in major and minor areas.

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

Students should consult with their academic adviser to file a program of study meeting these requirements prior to four months after initial registration for full-time students and prior to enrolling beyond 12 credits for part-time students.

Department of Electrical and Computer Engineering

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 field 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. Students whose accredited B.S. degree is not in electrical engineering or computer 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). Students should visit the appropriate department for course descriptions.

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 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 two credits of Master's Seminar (ECE 595 or ECE 596) and up to six credits of ECE short courses may be applied to the degree. Students arrange their program of study in consultation with their adviser 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, control systems, electromagnetics, electronics, networks, photonics and optics, power systems and signal processing.

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 a 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 proposed degree will follow the existing admission requirements for such professional master's degrees in 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), 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.

Students can pursue a professional master's degree in the area of Biomedical Imaging and Signals by completing the required core and elective courses.

Required Core Courses

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

ECE Elective Courses

minimum of 2 courses

ECE 508	Data Compression
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 Elective Courses

minimum of 1 course

BME 430	Concepts of Medical Imaging
BME 501	Biomedical Instrumentation
BME 532	Medical Imaging Science
BME 535	Magnetic Resonance Imaging
BME 538	Neuroimaging
BME 551	Physiological Signal Analysis & Control Theory I
BME 552	Physiological Signal Analysis & Control Theory II
BME 597	Wave Physics and Applied Optics for Imaging Scientist

With advisor's approval, students may take up to two senior or graduate level courses in biology, chemistry, mathematics, physics, chemical engineering, or mechanical engineering on subjects related to biomedical engineering.

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 the proposed degree will follow the existing admission requirements for such professional master's degrees in 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 2 credit hours of theMaster's Seminar (ECE 595 or ECE 596), 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.

Required Core Courses

(minimum of 3 courses):

ECE 564	Control and Operation of Electric Power Systems and/or ECE 420 Analytical Methods in Power Systems
ECE 551	Advanced Power Electronics and/or ECE 411 Power Electronics
ECE 419	Power Systems Analysis
ECE 412	Electric Motor Drives

Elective Courses in Power Systems

(minimum of 2 courses):

ECE 553	Power System Planning
ECE 554	Power Systems 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
CHE 543	Energy, Environment and Economics

Elective Courses in Power Electronics and Motor Drives

(minimum of 2 courses):

ECE 437	Digital Signal Processing I
ECE 438	Control Systems
ECE 531	Linear System Theory
ECE 549	Motion Control Systems Dynamics
ECE 550	Power Electronic Dynamics and Control
ECE 552	Adjustable Speed Drives
ECE 752	Industrial Applications of Power Electronics and Motor Drives
ECE 764	Vehicular Power Systems
CHE 541	Renewable Energy Technologies
CAE 524	Design Building Enclosures

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. 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 six 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.

The admission requirements for the proposed degree will follow the existing admission requirements for such professional master's degrees in 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.

Required Core Courses

(minimum of 4 core courses)

ECE 425	Analysis and Design of Integrated Circuits
ECE 429	Introduction to VLSI Design
ECE 529	Advanced VLSI Systems Design
ECE 575	Electron Devices and/or ECE 415 Solid-State Electronics

Computer Engineering Elective Courses

(minimum of one course)

ECE 485	Computer Organization and 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 Codesign
ECE 588	CAD Techniques for VLSI Design

Electronics Elective Courses

(minimum of one course)

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 578	Microwave Theory
ECE 579	Numerical Methods in Electromagnetics and Solid-State Electronics

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 program offered by the Department of Electrical and Computer Engineering (ECE) can be completed in one year of full-time study. 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 252 (Introduction to Differential Equations) MATH 474 (Probability), and CS 401 (Introduction to Advanced Studies in Computer Science). 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. is a focused professional master's degree requiring a minimum of 30 credit hours of adviser-approved coursework. The M.N.E. program of studies 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 six credit hours of adviser approved elective courses. At least 18 credit hours of the courses must be at the 500 level. A maximum of six credit hours may be taken from the ECE 700-level short courses.

Required courses

(12 credit hours)

ECE 407 Introduction to Computer Networks
AND/OR
ECE 545 Advanced Computer Networks
AND
ECE 511 Analysis of Random Signals
ECE 513 Communication Engineering Fundamentals
ECE 541 Performance Evaluation of Computer Networks
AND/OR
ECE 542 Design and Optimization of Computer Networks

Elective courses

(12 credit hours)

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

ECE 403 Communication Systems
ECE 404 Digital and Data Communications
ECE 437 Digital Signal Processing I
ECE 470 Photonics
ECE 485 Computer Organization and Design
ECE 504 Wireless Communication System Design
ECE 508 Signal and Data Compression
ECE 514 Digital Communication Principles
ECE 515 Modern Digital Communications
ECE 519 Coding for Reliable Communications
ECE 543 Computer Network Security
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 544 Computer Networks II: Network Services
CS 548 Broadband Networks

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.

Eligibility: A person holding a B.S.E.E., a B.S.CP.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	(i.e., CS 115 and CS 116 combined, Object Oriented Programming I-II)
CS 401	Introduction to Advanced Studies

Electrical and computer engineering prerequisites

ECE 211	Circuit Analysis I
ECE 213	Circuit Analysis II
ECE 308	Signals and Systems
MATH 252	Introduction to Differential Equations
MATH 474	Probability

The M.T.S.E. is a professional master's degree requiring a minimum of 30 credit hours of adviser-approved coursework. The M.T.S.E. program of studies must include a minimum of 15 credit hours of ECE coursework (excluding short courses and seminars) 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.

M.T.S.E. Curriculum

Required courses

ECE 407	Introduction to Computer Networks **AND/OR** ECE 545
ECE 545	Advanced Computer Networks
ECE 513	Communication Engineering Fundamentals
ECE 541	Performance Evaluation of Computer Networks **AND/OR** ECE 542
ECE 542	Design and Optimization of Computer Networks
CS 586	Software Systems Architecture
CS 587	Programming Project Management

Elective categories

I. Software Engineering

CS 521	Object-Oriented Analysis and Design
CS 537	Software Metrics
CS 589	Software Testing and Analysis

II. Telecommunication Systems

ECE 543	Computer Network Security
CS 544	Computer Networks II: Network Services
CS 548	Broadband Networks
CS 555	Analytic Models and Simulation of Computer Systems

III. Telecommunications

ECE 504	Wireless Communication System Design
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 M.T.S.E. adviser. Students without a background in communications or software engineering should consider including in their program of studies:

ECE 403	Communication Systems
CS 487	Software Engineering I
CS 450	Operating Systems I
CS 455	Data Communications

Other courses that students in this program typically choose from include:

ECE 437	Digital Signal Processing I
ECE 508	Signal and Data Compression
ECE 511	Analysis of Random Signals
ECE 515	Modern Digital Communications
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 adviser approval, the M.T.S.E. program of studies can include up to two credit hours of Master's Seminar (ECE 595, ECE 596). It can also include up to four credit hours of ECE short courses.

Master of Electricity Markets

30 credit hours

Deregulation is bringing major changes to the electric power industry. Electricity is now traded in commodity markets, and these new markets affect the way the electric power grid is controlled and operated. Electrical engineers need to understand both the technical and the business sides of these changes in order to address the needs of the electric power industry.

IIT's Department of Electrical and Computer Engineering and Center for Financial Markets have teamed up to develop new master's degree and graduate certificate programs in electricity markets. Combining existing and new courses from the graduate programs in electrical engineering and in financial markets and trading, the programs provide graduate-level education in electricity markets suitable for electric power engineers. The program of study includes a minimum of 30 credit hours of acceptable graduate coursework, with a minimum of 18 credit hours at the 500 level or higher (excluding accelerated courses and master's seminars). Up to two credits of Master's Seminar (ECE 595 or ECE 596) and up to six credits of accelerated courses may be applied to the degree. A background in finance is not required.

Curriculum

Core courses

ECE 555	Power Market Operations
ECE 561	Deregulated Power Systems
ECE 562	Power System Transaction Management
ECE 564	Control and Operation of Electric Power Systems
FM 553	Valuing Energy Derivatives
FM 552	Introduction to Energy Markets

Select two additional courses from the following:

ECE 419	Power System Analysis
ECE 420	Advanced Power System Analysis
ECE 550	Power Electronic Dynamics and Control
ECE 553	Power Systems Planning
ECE 554	Power Systems Relaying
ECE 556	Power Market Economics and Security
ECE 557	Fault-Tolerant Power Systems
ECE 558	Power System Reliability
ECE 559	High Voltage Power System Relaying
ECE 560	Power Systems Dynamics and Stability
ECE 563	Computational Intelligence in Engineering
ECE 531	Linear System Theory
ECE 537	Optimal Feedback Control

Six additional credit hours of electives are chosen from the offerings of the Department of Electrical and Computer Engineering, including the list of power courses above.

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 adviser 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. All students must complete the two doctoral seminar courses (ECE 695 and ECE 696), preferably early in their Ph.D. programs. 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 adviser, who may eventually serve as the thesis adviser and guides 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 consisting of 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 adviser, 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 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 fundamental 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 course work 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 adviser 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. All students must complete the two doctoral seminar courses (ECE 695 and 696), preferable early in their Ph.D. programs. 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 adviser, who many 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 consisting 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 digital and computer systems. 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 adviser, 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 baccalaureate knowledge in an area of specialization within electrical and computer engineering. Students in these programs register as certificate non-degree seeking students. 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 prerequisites. Any student admitted to a master's degree program offered by the department may apply coursework 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.

Elective courses

(Four from the following)

ECE 411	Power Electronics
ECE 414	Audio and Electroacoustics
ECE 425	Analysis and Design of Integrated Circuits
ECE 521	Quantum Electronics
ECE 524	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 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, electromagnetic wave propagation, antenna theory, and electromagnetic compatibility.

Required courses

ECE 421	Microwaves Circuits and Systems
OR	
ECE 423	Microwave Circuits and Systems with Laboratory
ECE 509	Electromagnetic Theory

Elective courses

(Two from the following)

ECE 522	Electromagnetic Compatibility
ECE 571	Nanodevices and Technology
ECE 576	Antenna Theory
ECE 577	Advanced Antenna Theory
ECE 578	Microwave Theory

Communication Systems

For those who want to become proficient in communication system principles and applications, this certificate program contains two fundamental courses and a large number of elective courses for emphasis in data compression, computer networks, and analog/digital communications. No more than one course may be a 400-level course.

Required courses

ECE 511 Analysis of Random Signals
ECE 513 Communication Engineering Fundamentals

Elective courses

(Two from the following)

ECE 403 Communication Systems
ECE 404 Digital Data Communications OR
ECE 406 Digital Data Communications with Laboratory
ECE 508 Signal and Data Compression
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
ECE 543 Computer Network Security
ECE 545 Advanced Computer Networks

Computer Systems

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 429 Introduction to VLSI Design AND/OR
ECE 529 Advanced VLSI Systems Design
AND
ECE 585 Advanced Computer Architecture

Elective courses

(Two from the following)

ECE 441 Microcomputers
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 545 Advanced Computer Networks
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

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

(Two from the following)

ECE 438 Control Systems OR
ECE 434 Control Systems with Laboratory
ECE 506 Analysis of Nonlinear Systems
ECE 537 Optimal Feedback Control
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.

Required courses

ECE 561 Deregulated Power Systems
FMT 540 Valuing and Managing Energy Derivatives
FMT 542 Introduction to Energy Markets
Two ECE accelerated courses

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 would be useful managers, engineers, and students who are seeking in power electronics related industry. A minimum credit hours including no more than four credit any one elective area must be taken. A maximum 400-level courses may be taken.

Required courses

(Choose at least two)
ECE 550 Power Electronic Dynamics and Control
ECE 551 Advanced Power Electronics
ECE 552 Adjustable Speed Drives
ECE 411 Power Electronics OR
ECE 412 Electric Motor Drives

Elective areas

I. Power area

ECE 561 Deregulated Power Systems
ECE 563 Computational Intelligence in Engineering
ECE 564 Control and Operation of Electric Power Systems

II. Electronics area

ECE 437 Digital Signal Processing I
ECE 575 Electron Devices

III. Control area

ECE 438 Control Systems
ECE 531 Linear System Theory
ECE 535 Discrete Time Systems

IV. Special topics area

Accelerated course(s) in power electronics

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.

Required course

(Choose one)
ECE 411 Power Electronics
ECE 412 Electric Motor Drives
ECE 419 Power Systems Analysis
ECE 420 Analytical Methods in Power Systems

Elective courses

(Choose three)
ECE 540 Reliability Theory and System Implementation
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 Systems 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

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 508 Signal and Data Compression
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 Communications 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; no more than one may be a 400-level course.)

ECE 403 Communication Systems
ECE 404 Digital & Data Communications
ECE 515 Modern Digital Communications
ECE 519 Coding For Reliable Communications
ECE 541 Performance Evaluation of Computer Networks
ECE 545 Advanced Computer Networks
ECE 576 Antenna Theory

Course Descriptions

Numbers in parentheses indicate class, lab and credit hours, respectively.

ECE 502
Basic Network Theory
Steady-state analysis of linear networks. Introduction to topology and the derivation of mesh, nodal and terminal pair relations using topological concepts with applications to computer-aided analysis of networks. Network interconnections. Indefinite admittance matrix. Prerequisite: B.S.E.E. degree. (3-0-3)

ECE 504
Wireless Communication System Design
Fundamentals of wireless communications, with emphasis on the underlying theory, design techniques, and analytical tools. Overview of wireless systems. Characteristics of wireless channels and their capacity limits. Audio, image and video coding standards. Modulation and coding for wireless channels. Diversity and Equalization techniques. Multiuser communications. Spread spectrum techniques. Multicarrier modulation. Wireless systems: Cellular systems: AMPS, TDMA, CDMA, and WCDMA - design, standards, performance studies. Wireless LAN systems (WiFi, WiMAX): design and standards. Prerequisite: ECE 513

ECE 505
Applied Optimization for Engineers
Principles of optimization for practical engineering problems, linear programming, nonlinear unconstrained optimization, nonlinear constrained optimization, dynamic programming. Prerequisite: B.S. degree in engineering, math orscience, or permission of instructor. (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. Prerequisite: Math 488. (3-0-3)

ECE 508
Signal and Data Compression
Elements of random signal processing and information theory. Noiseless compression techniques. Rate-distortion theory. Scalar and vector quantization; basic structures, asymptotic quantization theory, optimality criteria and design techniques. Structured vector quantization, product codes, tree/trellis codes, linear and nonlinear prediction, transform and subband coding, classified VQ. Selected applications: speech, audio, image and video coding. Prerequisites: ECE 437, 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: 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. Prerequisites: ECE 308 and ECE 475 or MATH 475. (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. Prerequisites: ECE 403 and ECE 475 or MATH 475. (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. Carrier and symbol synchronization. Signal design for band-limited channels. Prerequisites: ECE 511, 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. Multichannel and multicarrier signals for digital communications. Multiuser communications, time-division multiple access, code-division multiple access, frequency-division multiple access. Advanced communications systems. Prerequisite: ECE 511, ECE 513. (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. Turbo codes and low density parity check codes. Prerequisite: ECE 475 or MATH 475. (3-0-3)

ECE 521
Quantum Electronics
The Schrodinger equation. Matrix formulation. Quantization of lattice vibrations and electromagnetic fields. Optical beams and resonators. The interaction of radiation and atomic systems. Lasers. Optical waveguides and devices. Frequency conversion. Quantum noise. Same as PHYS 521. Prerequisite: ECE 307. (3-0-3)

ECE 522
Electromagnetic Compatibility
Development of design procedures for minimizing interference between electronic circuits and systems. sources of conducted and radiated interference. Interference coupling mechanisms. Shielding theory. Grounding, bonding and filtering methods. special equipment design procedures. Problems associated with digital equipment. Measurement methods. Prerequisites: ECE 307 or equivalent. (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. Prerequisites: ECE 309, 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, bandwidth estimation and stability analysis techniques. RF IFC team design projects. Prerequisites: ECE 312 and senior or graduate standing.

ECE 526
Active Filter Design
Analysis and design of linear active filters with emphasis on realizations using operational amplifiers. Sensitivity analysis. Switched capacitor filters. Prerequisites: ECE 308, 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 inter-modulation, 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. Prerequisites: ECE 312, Senior or Graduate student standing. (3-0-3)

ECE 529
Advanced VLSI Systems Design
Advanced design and application in VLSI Systems. The topics of this course include design tools and techniques, clocking issues, complexity management, layout and floorplanning, array structures, testing and testability, advanced arithmetic circuitry, transcendental function approximations, architectural issues, signal processing architectures, submicron design. Design project are completed and fabricated by student teams. Prerequisites: Graduate standing and ECE 429 or equivalent. (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. Prerequisites: Graduate standing and ECE 529 (3-0-3)

ECE 531
Linear System Theory
Linear spaces and operators, single and multivariable continuous dynamical systems, controllability and observability. Canonical forms, irreducible realizations. Synthesis of compensators and observers. Composite systems, elements of stability. Prerequisite: ECE 308. (3-0-3)

ECE 535
Discrete Time Systems
Discrete systems. Sampling and reconstruction procedures.Transform techniques of analysis andsynthesis. State space techniques. Discrete controllability,observability and stability.Compensation and digital controllers.Prerequisite: ECE 438. (3-0-3)

ECE 537
Optimal Feedback Control
Principles of feedback design for multivariable systems. Sensitivity functions, principal gains, operator norms and performance specification. Linear quadratic Gaussian (LQG) optimal control, loop transfer recovery (LTR) and design procedures with LQG/LTR methods. H-infinity optimal control, Hankel norm approximation, the 4-block problem, the Youla parameterization and design procedures with H-infinity methods. Prerequisites: ECE 438, ECE 531. (3-0-3)

ECE 540
Reliability Theory and 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. Prerequisites: ECE 308 and ECE 475 or MATH 475. (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 form queueing networks, approximation techniques for G/G/1 queues and non-product form queueing networks. Discrete event simulations, generation of random variables, variance reduction techniques and general purpose simulation languages. Prerequisite: ECE 475 or MATH 475. (3-0-3)

ECE 542
Design and 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: 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: ECE 407. (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: ECE 407. (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. Prerequisites: ECE 438 or permission of instructor. (3-0-3)

ECE 550
Power Electronic Dynamics and Control
Modeling and 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: ECE 411. (3-0-3)

ECE 551
Advanced Power Electronics
Advanced power electronic converters, techniques to model and control switching circuits, resonant converters, multi-level 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: 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 control 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: 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: ECE 419. (3-0-3)

ECE 554
Power Systems Relaying
Principles of relay protection for faults on transmission lines and in transformers, rotating machines and other equipment. Use of overcurrent, 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: ECE 419. (3-0-3)

ECE 555
Power Market Operations
Market design in restructured power systems, artificial neural network applications to power systems, short-term load forecasting, electricity price forecasting, price-based unit commitment, arbitrage in electricity market, gaming and market monitoring, asset valuation and risk analysis, security-constrained unit commitment, ancillary services auction, transmission pricing and regional transmission organizations. Prerequisite: ECE 419 (3-0-3)

ECE 556
Power Market Economics and 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. Prerequisites: ECE 420 or consent of instructor. (3-0-3).

ECE 557
Fault-Tolerant Power Systems
Critical fault events in a large power system, sparsity techniques. Contingency screening process. Modeling of local controls in load flow. Adaptive localization method. Injection outage analysis. Security constrained dispatch. LP-based OPF. Real-time security analysis. Dynamic security analysis. Prerequisite: ECE 419. (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: 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: ECE 419. (3-0-3)

ECE 560
Power Systems Dynamics and Stability
The transient stability problem, acceleration equations, stability criteria, two-machine and multi-machine problems. Perturbation analysis, eigenvalue sensitivity, Liapunov theory and application to power systems stability. Prerequisite: 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, RTO. Prerequisite: 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, interchange distribution calculator (IDC), congestion management, transmission loading relief (TLR). Prerequisite: 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, advanced engineering applications. Prerequisite: Graduate standing. (3-0-3)

ECE 564
Control and 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: ECE 419. (3-0-3)

ECE 565
Computer Vision and Image Processing
Multi-dimensional signal sampling and discrete Fourier transform; Image segmentation; Object boundary (edge) detection and description; Shape representation and extraction; Matching and recognition; Image registration; Camera geometry and stereo imaging; Morphological processing; Motion detection and compensation; Image modeling and transforms; Inverse problems in image processing (restoration and reconstruction). Prerequisite: ECE 437 and ECE 475 or MATH 475. (3-0-3)

ECE 566
Statistical Pattern Recognition
Review of appropriate math: multidimensional probability, covariance matrices, whitening transformation, diagonalization, eigenvectors, eigenvalues. Two-class and multi-class pattern separation using maximum

likelihood and MAP. Linear discriminant analysis. Perception algorithm and its extensions. Feature extraction algorithms. Clustering algorithms. Introduction to neural nets. Hopfield, Hamming, feedforward models. Training of neural nets. Prerequisite: ECE 511. (3-0-3)

ECE 567
Statistical Signal Processing
Detection theory and hypothesis testing. Introduction to estimation theory. Properties of estimators, Gauss-Markov theorem. Estimation of random variables: conditional mean estimates, linear minimum mean-square estimation, orthogonality principle, Wiener and Kalman filters. Adaptive filtering. LMS algorithm: properties and applications. Prerequisites: ECE 511, MATH 333. (3-0-3)

ECE 568
Digital Speech Processing
Review of discrete statistical signal analysis. Acoustic aspects of speech and hearing. Digital models of speech production. Short-time processing in time and frequency domains. Waveform encoding and linear predictive coding of speech. Estimation of fundamental speech parameters. Applications including automatic speech recognition and enhancement. Prerequisites: ECE 437, ECE 511. (3-0-3)

ECE 569
Digital Signal Processing II
Review of basic DSP theory. Design of digital filters: FIR, IIR, frequency-transformation methods, optimal methods. Discrete Fourier Transform (DFT) and Fast Fourier Transform algorithms. Spectral estimation techniques, classical and parametric techniques. AR, MA, ARMA models. Estimation algorithms. Levinson, Durbin-Levinson and Burg s algorithms. Eigenanalysis algorithms for spectral estimation. Prerequisites: ECE 437 and ECE 475 or MATH 475. (3-0-3)

ECE 570
Fiber-Optic Communication Systems
Physics of optical fiber, composition, dimensioning, coupling, attenuation, dispersion. Electro-optical conversion devices (ILDs, LEDs, APDs, PINs). Circuit considerations. Modulation techniques and implications. Overall system considerations. Coherent techniques. Prerequisites: ECE 307, ECE 309, ECE 312, ECE 403. (3-0-3)

ECE 571
Nanodevices and Technology
Electronic properties and quantum effects; Dielectric, magnetic and optical properties and their characterizations; Individual nanoparticles and clusters; Carbon nanotubes; Solid disordered nanostructures; Nanostructured crystals; Quantum wells, wires and dots; Giant magnetoresistance; Material processing techniques; Devices and systems based on nanostructures. Prerequisites: B.S. degree with knowledge on quantum mechanics and thermodynamics. (3-0-3)

ECE 575
Electron Devices
Electronic properties of solids. Properties of p-n junctions and junction devices. Gunn diode and IMPATT devices. Junction transistors. Schottky diode and MESFET. The MOS capacitor and MOSFET. Light-emitting diodes and junction lasers. Velocity modulation and bunching in electron beams. Klystrons, magnetrons and other microwave thermionic devices. Prerequisites: ECE 307, 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. Prerequisites: ECE 309, ECE 421 or ECE 423. (3-0-3)

ECE 577
Advanced Antenna Theory
Optimal design of Yagi antennas, traveling wave antennas and large loops. Broadband antennas based on log periodic principles. Numerical methods to solve antenna problems. Aperture antennas. Prerequisite: ECE 576. (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: ECE 421 or ECE 423. (3-0-3)

ECE 579
Numerical Methods in Electromagnetics and Solid-State Electronics
Complete and self-contained treatment of the numerical methods used in the design and analysis of high frequency devices and components. The numerical techniques applicable to electromagnetic field theory and charge transport models are thoroughly discussed by integrating them in a global modeling frame-work. After introducing Maxwell's equations and Boltzmann's transport equation, a detailed discussion will be offered of numerical techniques, such as classic iterative methods, finite differences, finite elements, multigrid, particle-based models, and automative mesh generation. Prerequisite: ECE 307 or instructor's consent.

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. 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. Prerequisites: ECE 485. (3-0-3)

ECE 584
VLSI Architectures for Signal Processing and Communications
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 kernels. 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: ECE 429 and ECE437. (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 Interactions. Prerequisite: Graduate standing or faculty consent. (3-0-3)

ECE 586
Fault Detection in Digital Circuits
Essential elements in testing and testability of digital designs. Automatic test generation algorithms and fault-simulation methods. Design methodologies to increase testability and decrease test generation costs. Techniques for built-in testing. Prerequisite: 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. Prerequisites: CS 200, ECE 441, graduate standing. (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: ECE 427, ECE 429 or ECE 530. (3-0-3)

ECE 591
Research and Thesis for M.S. Degree

ECE 594
Special Projects

ECE 595|
Master's Seminar I
(1-0-1)

ECE 596
Master's Seminar II
(1-0-1)

ECE 597
Special Problems

ECE 604
Advanced Topics in Network Synthesis
A seminar course dealing with current topics in network synthesis. Topics covered include advanced approximation theory, active network synthesis, and research conducted by faculty and students. Prerequisite: ECE 502. (3-0-3)

ECE 622
Advanced Topics in Electronic Systems
Course content is variable, depending on state of the art and design and research trends. Prerequisites: ECE 506. (3-0-3)

ECE 631
Advanced Topics in Automatic Control
Course content is variable and reflects the current trends in automatic control, system and optimal filtering theory. Prerequisites: ECE 438, ECE 531. (3-0-3)

ECE 643
Advanced Topics in Computer Networks
Course content is variable and reflects the current trends in computer networks. Prerequisite: ECE 545. (3-0-3)

ECE 650
Advanced Topics in Power Systems
Course content is variable and reflects the current trends in power systems. Prerequisite: ECE 419. (3-0-3)

ECE 669
Advanced Topics in Signal Processing
Course content is variable and reflects the current trends in signal processing including digital and optical systems. Prerequisite: ECE 569. (3-0-3)

ECE 671
Advanced Topics in Communication Theory
Course is concerned with modern advances and specialized topics in communication theory. Topics include current research of faculty and students. Prerequisite: ECE 513. (3-0-3)

ECE 691
Research and Thesis for Ph.D. Degree

ECE 695
Doctoral Seminar I
(1-0-1)

ECE 696
Doctoral Seminar II
(1-0-1)

Undergraduate Courses Available to Graduate Students

ECE 401
Communication Electronics

ECE 403
Communication Systems I

ECE 404
Digital and Data Communications

ECE 406
Digital and Data Communications with Laboratory

ECE 407
Introduction to Computer Networks

ECE 409
Communication Electronics with Laboratory

ECE 411
Power Electronics

ECE 412
Electric Motor Drives

ECE 414
Audio and Electroacoustics

ECE 419
Power Systems Analysis

ECE 420
Analytical Methods in Power Systems

ECE 421
Microwaves

ECE 423
Microwave Circuits and Systems

ECE 425
Analysis and Design of Integrated Circuits

ECE 429
Introduction to VLSI Design

ECE 434
Control Systems with Laboratory

ECE 436
Digital Signal Processing I with Laboratory

ECE 437
Digital Signal Processing I

ECE 438
Control Systems

ECE 441
Microcomputers

ECE 446
Advanced Logic Design

ECE 448
Computer Systems Programming

ECE 449
Object-Oriented Programming and Computer Simulation

ECE 470
Photonics

ECE 471
Photonics with Laboratory

ECE 475
Random Phenomena in Electrical Engineering

ECE 481
Image Processing

ECE 485
Computer Organization and Design