Stevens Institute of Technology 2006-2007 Catalog

The Charles V. Schaefer, Jr. School of Engineering

Department of Electrical and Computer Engineering

STUART K. TEWKSBURY, DIRECTOR

FACULTY*

Professors

Francis T. Boesch, Ph.D. (1963), Polytechnic Institute of Brooklyn
Harry Heffes, Ph.D. (1968), New York University
Victor Lawrence, Ph.D. (1972), University of London
Stuart K. Tewksbury, Ph.D. (1969), University of Rochester

Associate Professor

Rajarathnam Chandramouli, Ph.D. (1999), University of South Florida
Hongbin Li, Ph.D. (1999), University of Florida
Yu-Dong Yao, Ph.D. (1988), Southeast University, China

Assistant Professors

Cristina Comaniciu, Ph.D. (2001), Rutgers University
Yi Guo, Ph.D. (1999), University of Sydney
Haibo He, Ph.D. (2006), Ohio University
Hong Man, Ph.D. (1999), Georgia Institute of Technology
Yan Meng, Ph.D. (2000), Florida Atlantic University
Nader Mohamed, Ph.D. (2004), University of Nebraska-Lincoln
K. P. Subbalakshmi, Ph.D. (2000), Simon Fraser University
Uf Tureli, Ph.D. (2000), University of Virginia

Special Faculty

Barry Bunin, Ph.D., (1970), Polytechnic Institute of Brooklyn
Chandra M. R. Kintala, Ph.D. (1977), Pennsylvania State University

Travel Directions

Campus Map

Bruce McNair, M.E. (1974), Stevens Institute of Technology

Professors Emeriti

Gerald J. Herskowitz, Eng. Sc.D. (1963), New York University
Emil C. Neu, D.Eng.Sc (1966), Newark College of Engineering
Harrison E. Rowe, Sc.D. (1952), Massachusetts Institute of Technology
Stanley H. Smith, Ph.D. (1965), New York University

* The list indicates the highest earned degree, year awarded, and institution where earned.

UNDERGRADUATE PROGRAMS

Electrical Engineering

Today's technological world is driven by the electronics and electronic systems, developed and advanced by electrical engineers, that are found embedded in a large portion of today's commercial and consumer products. The electronic systems and subsystems (including both hardware and software components) are increasing exponentially in complexity and sophistication each year. The familiar expectation that next year's computer and communications products will be far more powerful than today's is common to all products incorporating electronics. The high (and increasing) complexity and sophistication of these electronic products may not be seen by the casual user, but they are understood, delivered, and advanced by electrical engineers. The field of electrical engineering encompasses areas such as telecommunications, data networks, signal processing, digital systems, embedded computing, intelligent systems, electronics, optoelectronics, solid state devices, and many others. The Department's program is designed to provide our electrical engineering graduates with the tools and skills necessary to understand and apply today's technologies and to become leaders in developing tomorrow's technologies and applications.

The principles and practices of electrical engineering rest upon the broad base of fundamental science and mathematics that defines the School of Engineering's core program. A sequence of electrical engineering courses provides the student with an understanding of the major themes defining contemporary electronic systems, as well as depth in the mathematics and principles of today's complex electronic systems. Students select elective courses to develop depth in areas of personal interest. In addition to electrical engineering elective courses, the student can draw upon computer engineering and other Stevens courses to develop the skills appropriate for their career objectives. In the senior year, students complete a significant, team-based engineering design project through which they further develop their skills.

Mission and Objectives

The mission of the undergraduate electrical engineering program in the Department of Electrical and Computer Engineering is to provide a balanced education in fundamental principles, design methodologies, and practical experiences in electrical engineering and in general engineering topics through which the graduate can enter into and sustain a lifelong professional career of innovation and creativity.

The overriding objective of the electrical engineering program is to provide the graduate with the skills and understanding needed to design and build innovative new products and services which balance the rival requirements of competitive performance/cost and practical constraints imposed by available technologies.

Graduates of the Electrical Engineering program will:

- Understand the evolving electronic devices and systems from their underlying physical principles and properties.
- Design electronic devices, circuits, and systems by applying underlying mathematical principles, software principles, and engineering models.
- Perform effectively in team-based electronic engineering practice.
- Be proficient in the systematic explorations of alternatives for electronic systems design.
- Demonstrate compliance with professional ethics, for example, as stipulated in the IEEE Code of Ethics.
- Be proficient in the use of communications (oral presentations and written reports) to articulate their ideas effectively.
- Participate in continuing learning and self-improvement necessary for a productive career in computer engineering.
- Play leadership roles in their professions.

back to top

Course Sequence

The template of the electrical engineering curriculum is as follows:

Freshman Year	
Term I	
	Hrs. Per Wk.

		Class	Lab	Study	Sem. Cred.
CH 115	General Chemistry I	3	0	6	3
CH 117	General Chemistry Lab I	0	3	0	1
MA 115	Calculus I	3	0	6	3
E 101	Eng. Experiences I #	1	0	0	0
E 121	Engineering Design I	0	3	2	2
E 120	Engineering Graphics	0	2	2	1
E 115	Intro. To Programming	1	1.5	3	2
HUM	Humanities	3	0	6	3
	# credit applied in E102				
TOTAL		**11**	**9.5**	**25**	**15**

Term II					
		Hrs. Per Wk.			
		Class	Lab	Study	Sem. Cred.
Science	Science Elective I (1)	3	0	6	3
E 102	Eng. Experiences II #	1	0	0	1
MA 116	Calculus II	3	0	6	3
PEP 111	Physics I	3	0	6	3
E 122	Engineering Design II	0	3	3	2
HUM	Humanities	3	0	6	3
	# credit for E101 & 102				
TOTAL		**13**	**3**	**27**	**15**

Sophomore Year					
Term III					
		Hrs. Per Wk.			
		Class	Lab	Study	Sem. Cred.
MA 221	Differential Equations	4	0	8	4
PEP 112	Physics II	3	0	6	3

E 126	Mechanics of Solids	4	0	8	4
E 245	Circuits & Systems	2	3	7	3
E 231	Engineering Design III	0	3	2	2
HUM	Humanities	3	0	6	3
TOTAL		**16**	**6**	**37**	**19**

Term IV					
		Hrs. Per Wk.			
		Class	Lab	Study	Sem. Cred.
EE 250	Math for Electrical Eng.**	3	0	6	3
E 232	Engineering Design IV	2	3	7	3
E 234	Thermodynamics**	3	0	6	3
EE 359	Electronic Circuits	3	0	6	3
CPE 390	Microprocessor Systems	3	3	7	4
HUM	Humanities	3	0	6	3
TOTAL		**17**	**6**	**38**	**19**

Junior Year					
Term V					
		Hrs. Per Wk.			
		Class	Lab	Study	Sem. Cred.
EE 471	Transport Phenomena in Solid State Devices	4	0	8	4
E 344	Materials Processing	3	0	6	3
E 321	Engineering Design V	0	3	2	2
E 243	Prob. & Statistics	3	0	6	3
EE 348	Systems Theory	3	0	6	3
HUM	Humanities	3	0	6	3

TOTAL		**16**	**3**	**34**	**18**

Term VI					
		Hrs. Per Wk.			
		Class	Lab	Study	Sem. Cred.
EE 345	Modeling & Simulation ‡	3	0	6	3
E 355	Engineering Economics	3	3	6	4
EE 322	Engineering Design VI ‡	1	3	5	2
Science	Science Elective II (1)	2	3	7	3
EE 448	Digital Signal Processing	3	0	6	3
G.E.	General Elective (2)	3	0	6	3
TOTAL		**15**	**9**	**36**	**18**

Senior Year					
Term VII					
		Hrs. Per Wk.			
		Class	Lab	Study	Sem. Cred.
T.E.	Technical Elective ‡	3	0	6	3
EE 465	Intro. to Communication Systems	3	0	6	3
G.E.	General Elective (2)	3	0	6	3
EE 423	Engineering Design VII‡	0	8	4	3
T.G.	Technogenesis Core**	3	0	6	3
T.E.	Technical Elective ‡	3	0	6	3
Total		**15**	**8**	**34**	**18**
Term VIII					
		Hrs. Per Wk.			
		Class	Lab	Study	Sem. Cred.
T.E.	Technical Elective ‡	3	0	6	3
T.E.	Technical Elective ‡	3	0	6	3

G.E.	General Elective (2)	3	0	6	3
EE 424	Engineering Design VIII ‡	0	8	4	3
HUM	Humanities	3	0	6	3
TOTAL		**12**	**8**	**28**	**15**

** Core option – specific course determined by engineering program
‡ Discipline-specific course
(1) Basic Science electives – note: engineering programs may have specific requirements
- one elective must have a laboratory component
- two electives from the same science field cannot be selected
(2) General Education Electives – chosen by the student
- can be used towards a minor or option
- can be applied to research or approved international studies

GRADUATION REQUIREMENTS

The following are requirements for graduation of all engineering students and **are not included for academic credit**. They will appear on the student record as pass/fail.

Physical Education

All engineering students must complete a minimum of three semester credits of Physical Education (P.E.). A large number of activities are offered in lifetime, team, and wellness areas. Students must complete at least one course in their first semester at Stevens; the other two can be completed at any time, although it is recommended that this be done within the first half of the student's program of study. Students can enroll in more than the minimum required P.E. for graduation and are encouraged to do so.

Participation in varsity sports can be used to satisfy the full P.E. requirement.

Participation in supervised, competitive club sports can be used to satisfy up to two credits of the P.E. requirement with approval from the P.E. Coordinator.

English Language Proficiency

All students must satisfy an English Language proficiency requirement.

PLEASE NOTE: *A comprehensive Communications Program will be implemented for the Class of 2009. This may influence how the English Language Proficiency requirement is met. Details will be added when available.*

back to top

Electives

"Technical electives" are generally selected from among the courses (EE or CPE) listed among the ECE course descriptions. Under special circumstances, students may be allowed to use courses from other departments to satisfy the technical elective requirement: approval by the course instructor, the student's advisor, and the ECE Director is required.

"Electives" are free electives, and can be selected from among any courses (including ECE courses) at Stevens Institute of Technology. Students can use 500-level ECE courses to satisfy an elective requirement, with the permission of the course instructor and the student's advisor. If a student satisfies the conditions established by the Stevens Graduate School for admission into 600-level graduate courses, ECE 600-level courses may also be used as electives or technical electives. Students interested in using a 500-level or 600-level course from other departments as a free elective must satisfy the conditions for admission into the course by the offering department.

"Special Topics" graduate courses offered by other departments may not be taken for credit towards the B.E. in Electrical Engineering.

Computer Engineering

One of the most rapidly growing fields today is computer engineering. This includes the design, development, and application of digital and computer-based systems for the solution of modern engineering problems, as well as computer software development, data structures and algorithms, and computer communications and graphics. The department provides our computer engineering students with the tools and skills necessary to understand and apply today's technologies and to become leaders in developing tomorrow's technologies. The program prepares students to pursue professional careers in industry and government, and to continue their education in graduate school, if they choose.

Students in the computer engineering program begin by studying the scientific foundations that are the basis for all engineering. Specialized electrical engineering, computer engineering, and computer science courses follow, providing depth in the many issues related to computers, data networks, information systems, and related topics used in contemporary commercial and industrial applications. Students may direct their interests into areas such as computer and information systems, software/software engineering, and computer architectures and digital systems. In addition to computer engineering courses, the student can draw upon electrical engineering and computer science courses to develop the skills appropriate for their career objectives. In the senior year, students have the opportunity to participate in an actual engineering design project which is taken directly from a current industrial or commercial application.

back to top

Mission and Objectives

The mission of the undergraduate computer engineering program in the Department of Electrical and Computer Engineering is to provide a balanced education in fundamental principles, design methodologies, and practical experiences in computer engineering, general engineering, and physical and mathematical sciences topics through which the graduate can enter into and sustain a lifelong professional career of engineering innovation and creativity. Computer engineering integrates those elements of electrical engineering and computer science that underlie the hardware-software interface in computing and information systems.

The overriding objective of the computer engineering program is to provide the graduate with the skills and understanding needed to design and build innovative new products and services. They balance the rival requirements of competitive performance/cost and practical constraints imposed by available technologies. Graduates of the computer engineering program will:

- Apply the underlying principles and practices of digital circuits and systems, including design techniques, engineering design tools, mathematical methods, and physical technologies.
- Participate effectively in team-based approaches to design, verification, and realization tasks.
- Be proficient in the systematic exploration of the design space to achieve optimized designs.
- Demonstrate compliance with professional ethics (for example, as stipulated in the IEEE Code of Ethics).
- Be proficient in the use of communications (oral presentations and written reports) to articulate their ideas effectively.
- Participate in continuing learning and self-improvement necessary for a productive career in computer engineering.
- Play leadership roles in their professions.

back to top

Course Sequence

The template of the computer engineering curriculum is as follows:

Freshman Year
Term I

		Hrs. Per Wk.			
		Class	Lab	Study	Sem. Cred.
CH 115	General Chemistry I	3	0	6	3
CH 117	General Chemistry Lab I	0	3	0	1
MA 115	Calculus I	3	0	6	3
E 101	Eng. Experiences I #	1	0	0	0
E 121	Engineering Design I	0	3	2	2
E 120	Engineering Graphics	0	2	2	1
E 115	Intro. to Programming	1	1.5	3	2
HUM	Humanities	3	0	6	3
	# credit applied in E102				
TOTAL		**11**	**9.5**	**25**	**15**

Term II					
		Hrs. Per Wk.			
		Class	Lab	Study	Sem. Cred.
Science	Science Elective I (1)	3	0	6	3
E 102	Eng. Experiences II #	1	0	0	1
MA 116	Calculus II	3	0	6	3
PEP 111	Physics I	3	0	6	3
E 122	Engineering Design II	0	3	3	2
HUM	Humanities	3	0	6	3
	# credit for E 101 & 102				
TOTAL		**13**	**3**	**27**	**15**

Sophomore Year					
Term III					
		Hrs. Per Wk.			
		Class	Lab	Study	Sem. Cred.
MA 221	Differential Equations	4	0	8	4

PEP 112	Physics II	3	0	6	3
E 126	Mechanics of Solids	4	0	8	4
E 245	Circuits & Systems	2	3	7	3
E 231	Engineering Design III	0	3	2	2
HUM	Humanities	3	0	6	3
TOTAL		**16**	**6**	**37**	**19**

Term IV					
		Hrs. Per Wk.			
		Class	Lab	Study	Sem. Cred.
MA 134	Discrete Math**	3	0	6	3
E 232	Engineering Design IV	2	3	7	3
E 234	Thermodynamics**	3	0	6	3
CPE 360	Comp. Data Struct. & Alg.	3	0	6	3
CPE 390	Microprocessor Systems	3	3	7	4
HUM	Humanities	3	0	6	3
TOTAL		**17**	**6**	**38**	**19**

Junior Year					
Term V					
		Hrs. Per Wk.			
		Class	Lab	Study	Sem. Cred.
EE 471	Transport Phenomena in Solid State Devices	4	0	8	4
E 344	Materials Processing	3	0	6	3
E 321	Engineering Design V	0	3	2	2
E 243	Prob. & Statistics	3	0	6	3
CPE 487	Digital System Design	3	0	6	3
HUM	Humanities	3	0	6	3

TOTAL	**16**	**3**	**34**	**18**

Term VI					
		Hrs. Per Wk.			
		Class	Lab	Study	Sem. Cred.
CPE 345	Modeling & Simulation ‡	3	0	6	3
E 355	Engineering Economics	3	3	6	4
CPE 322	Engineering Design VI ‡	1	3	5	2
CPE 462	Image Proc. & Coding	3	0	6	3
Science	Science Elective II (1)	3	0	6	3
G.E.	General Elective (2)	3	0	6	3
TOTAL		**16**	**6**	**35**	**18**

Senior Year					
Term VII					
		Hrs. Per Wk.			
		Class	Lab	Study	Sem. Cred.
T.E.	Technical Elective ‡	3	0	6	3
CPE 490	Info. Sys. Engineering I	3	0	6	3
G.E.	General Elective (2)	3	0	6	3
CPE 423	Engineering Design VII‡	0	8	4	3
T.G.	Technogenesis Core**	3	0	6	3
T.E.	Technical Elective ‡	3	0	6	3
Total		**15**	**8**	**34**	**18**
Term VIII					
		Hrs. Per Wk.			
		Class	Lab	Study	Sem. Cred.
T.E.	Technical Elective ‡	3	0	6	3

T.E.	Technical Elective ‡	3	0	6	3
G.E.	General Elective (2)	3	0	6	3
CPE 424	Engineering Design VIII ‡	0	8	4	3
HUM	Humanities	3	0	6	3
TOTAL		**12**	**8**	**28**	**15**

** Core option – specific course determined by engineering program
‡ Discipline-specific course
(1) Basic Science electives – note: engineering programs may have specific requirements
- one elective must have a laboratory component
- two electives from the same science field cannot be selected
(2) General Education Electives – chosen by the student
- can be used towards a minor or option
- can be applied to research or approved international studies

GRADUATION REQUIREMENTS

The following are requirements for graduation of all engineering students and **are not included for academic credit**. They will appear on the student record as pass/fail.

Physical Education

All engineering students must complete a minimum of three semester credits of Physical Education (P.E.). A large number of activities are offered in lifetime, team, and wellness areas. Students must complete at least one course in their first semester at Stevens; the other two can be completed at any time, although it is recommended that this be done within the first half of the student's program of study. Students can enroll in more than the minimum required P.E. for graduation and are encouraged to do so.

Participation in varsity sports can be used to satisfy the full P.E. requirement.

Participation in supervised, competitive club sports can be used to satisfy up to two credits of the P.E. requirement with approval from the P.E. Coordinator.

English Language Proficiency

All students must satisfy an English Language proficiency requirement.

PLEASE NOTE: *A comprehensive Communications Program will be implemented for the Class of 2009.This may influence how the English Language Proficiency requirement is met. Details will be added when available.*

back to top

Electives

"Technical electives" are generally selected from among the courses (EE or CPE) listed among the ECE course descriptions. Under special circumstances, students may be allowed to use courses from other departments to satisfy the technical elective requirement: approval by the course instructor, the student's advisor, and the ECE Director is required.

"Electives" are free electives, and can be selected from among any courses (including ECE courses) at Stevens. Students can use 500-level ECE courses to satisfy an elective requirement, with the permission of the course instructor and the student's advisor. If a student satisfies the conditions established by the Stevens Graduate School for admission into 600-level graduate courses, ECE 600-level courses may also be used as electives or technical electives. Students interested in using a 500-level or 600-level course from another department as a free elective must satisfy the conditions for admission into the course by the offering department.

"Special Topics" graduate courses offered by other departments may not be taken for credit towards the B.E. in Electrical Engineering.

Minors

A student may qualify for a minor in Electrical Engineering or Computer Engineering by taking the required courses indicated below. Completion of a minor indicates a proficiency beyond that provided by the Stevens curriculum in the basic material of the selected area. Enrollment in a minor program means that the student must also meet Stevens' requirements for minor programs.

If one majors in Computer Science, (s)he cannot minor in Computer Engineering. Similarly, if one majors in Computer Engineering, (s)he cannot minor in Computer Science. Only courses completed with a grade of "C" or better are accepted towards a minor.

Requirements for a Minor in Electrical Engineering

CPE 358 Switching Theory and Logical Design
CPE 390 Microprocessor Systems
E 246 Electronics and Instrumentation
EE 348 Systems Theory
EE 465 Introduction to Communications

Requirements for a Minor in Computer Engineering

CPE 358 Switching Theory and Logical Design
CPE 360 Computational Data Structures & Algorithms
CPE 390 Microprocessor Systems
CPE 490 Information Systems Eng. I
E 246 Electronics and Instrumentation

back to top

LABORATORIES

Undergraduate laboratories in the Department of Electrical and Computer Engineering are used for course-related teaching. Laboratory assignments expose students to a range of practical problems. The Elsie Hattrick Design Laboratory is used for the study of electronic circuits, sensor/transducer systems, and other topics. The Microelectronic Systems Laboratory is used for the study of microprocessor/embedded systems, digital signal processing, VLSI/FPGA systems, and other systems-based courses.

All research laboratories serve a dual-use function: undergraduate students use these facilities for special course-related projects and senior design; graduate students use them for course-related projects and thesis research. For a listing of our research laboratories, available with appropriate approval for undergraduate student projects, please refer to the section entitled "**Research Environment**" in this catalog.

GRADUATE PROGRAMS

The mission of the Department of Electrical and Computer Engineering (ECE) is to provide students with the tools and skills necessary to understand and apply today's technologies and to become leaders in developing tomorrow's technologies and applications. To this end, programs have been developed to ensure that students receive both fundamental knowledge in basic concepts and an understanding of current and emerging/future technologies and applications.

The Electrical and Computer Engineering (ECE) department offers the degrees of Master of Engineering (Electrical Engineering), Master of Engineering (Computer Engineering), Master of Engineering (Networked Information Systems), the degree of Electrical Engineer, and the degree of Computer Engineer. In addition, the degree of Doctor of Philosophy is offered in Electrical Engineering and in Computer Engineering.

The faculty engage in a variety of research efforts, such as telecommunications, data networks, information systems, wireless networks, including architectures and principles, signal processing, including communications applications, channel/signal estimation and detection, image processing and coding for images and video, multimedia systems and environments, computational system architectures, reconfigurable systems, secure data communications, network analysis and modeling, optical communication systems, and low-power mobile systems.

back to top

Master of Engineering - Electrical Engineering

In general, a bachelor's degree in electrical engineering or computer engineering with a minimum grade point average of 3.0 on a 4.0 scale is required for graduate study in electrical engineering. Outstanding applicants with degrees in other engineering disciplines, physics, or mathematics may be conditionally admitted subject to the completion of appropriate ramp courses or their equivalents with a grade of "B" or better. The specific requirements will be determined on an individual basis depending on the student's background. Submission of GRE scores is recommended, but not required.

The master's degree requires completion of a total of 30 hours of credit. Each student must complete the three core courses and must complete the course requirements for one of the electrical engineering concentrations. Elective courses are to be chosen from among the EE, CPE, and NIS numbered graduate courses in this catalog. An elective course not in the CPE , EE, or NIS numbered courses may be taken, with the approval of the student's academic advisor. A maximum of two elective courses not listed in the ECE program may be taken with the approval of the academic advisor.

Electrical Engineering Core Courses:

EE 602 Analytical Methods in Electrical Engineering
EE 603 Linear Systems Theory
EE 605 Probability and Stochastic Processes I

Electrical Engineering Concentrations:

Those students selecting one of the departmental concentration areas must complete a three-course concentration sequence appropriate for any one of the following concentration areas. Recommended courses are listed with each concentration. (Approval by the student's advisor is required to substitute another course for a listed course.)

Autonomous Robotics

Required:

CPE 521 Autonomous Mobile Robotic Systems
EE 631 Cooperating Autonomous Mobile Robots

Choose two from the following list with approval from an ECE advisor:

CPE 555 Real-time and Embedded Systems
CPE 645 Image Processing and Computer Vision

EE 583 Wireless Communications
EE 621 Nonlinear Control

Computer Architectures and Digital Systems

CPE 514 Computer Architecture
CPE 643 Logic Design of Digital Systems I
CPE 690 Introduction to VLSI Design

Embedded Systems

CPE 555 Real-time and Embedded Systems
CPE 621 Analysis and Design of Real-Time Systems
CPE 690 Introduction to VLSI Design
EE 627 Data Acquisition and Processing I

Microelectronic Devices and Systems

CPE 690 Introduction to VLSI Design
EE 503 Introduction to Solid State Physics
EE 619 Solid State Devices

Signal Processing for Communications

EE 613 Digital Signal Processing for Communications
EE 615 Multicarrier Communications
EE 616 Signal Detection and Estimation for Communications
EE 663 Digital Signal Processing I
EE 664 Digital Signal Processing II

Telecommunications Systems Engineering

CPE 655 Queuing Systems with Computer Applications I
EE 606 Probability and Stochastic Processes II
EE 609 Communication Theory
EE 610 Error Control Coding for Networks
EE 670 Information Theory and Coding

Wireless Communications

EE 583 Wireless Communications
EE 584 Wireless Systems Security
EE 585 Physical Design of Wireless Systems
EE 586 Wireless Networking: Architectures, Protocols and Standards
EE 651 Spread Spectrum and CDMA
EE 653 Cross-Layer Design for Wireless Networks

Interdepartmental Concentration in Microelectronics and Photonics Science and Technology:

Students selecting this concentration must complete the core course and three of the concentration's allowed elective courses listed below (see asterisk note).

Concentration Core Course:

EE 507 Introduction to Microelectronics and Photonics

Allowed Concentration Electives:

CPE 690 Introduction to VLSI Design*
EE 585 Physical Design of Wireless Systems*
EE 626 Optical Communication Systems*
MT 562 Solid State Electronics II
MT 595 Reliability and Failure of Solid State Devices
MT 596 Microfabrication Techniques
PEP 503 Introduction to Solid State Physics
PEP 515 Photonics I
PEP 516 Photonics II
PEP 561 Solid State Electronics I

* These courses do not count towards the Microelectronics and Photonics concentration for ECE students (they do count as electives for the full master's program).

For further information on recommended elective courses under each concentration, refer to the Computer Engineering graduate program brochure, the ECE Web page, or consult with an academic advisor.

back to top

Master of Engineering - Computer Engineering

In general, a bachelor's degree in electrical engineering or computer engineering with a minimum grade point average of 3.0 on a 4.0 scale is required for graduate study in computer engineering. Outstanding applicants in other areas may be conditionally admitted subject to the completion of appropriate ramp courses or their equivalents with a grade of "B" or better. The specific requirements will be determined on an individual basis depending upon the student's background. Submission of GRE scores is recommended, but not required.

The master's degree requires completion of a total of 30 hours of credit. Each student must complete the three core courses and must complete the course requirements for one of the computer engineering concentrations. Elective courses are to be chosen from among the CPE, EE, and NIS numbered graduate courses in this catalog. An elective course not in the CPE, EE, or NIS numbered courses may be taken, with the approval of the student's academic advisor. A maximum of two elective courses not listed in the ECE program may be taken with the approval of the academic advisor.

Computer Engineering Core Courses (Select three of the following courses)

CPE 645 Image Processing and Computer Vision
CPE 654 Design and Analysis of Network Systems
CPE 690 Introduction to VLSI Systems Design
CPE 593 Applied Data Structures and Algorithms
EE 612 Principles of Multimedia Compression

Computer Engineering Concentrations Courses:

Each student must complete a three-course concentration sequence appropriate for any one of the following concentration areas. Recommended courses are listed with each concentration. A course used as a core course cannot be used also to satisfy the requirement for three courses in a concentration. (Approval by the student's advisor is required to substitute another course for a listed course.)

Computer Systems

CPE 540 Fundamentals of Quantitative Software Engineering I
CPE 644 Logical Design of Digital Systems II
CPE 654 Design and Analysis of Network Systems
EE 653 Cross-Layer Design for Wireless Networks

Data Communications and Networks

CPE 565 Management of Local Area Networks
CPE 654 Design and Analysis of Network Systems
CPE 678 Information Networks I
CPE 655 Queuing Systems with Computer Applications I
EE 653 Cross-Layer Design for Wireless Networks
NIS 584 Wireless Systems Security

Digital Systems Design

CPE 621 Analysis and Design of Real-Time Systems
CPE 644 Logical Design of Digital Systems II
CPE 690 Introduction to VLSI Systems Design

Image Processing and Multimedia

CPE 558 Computer Vision
CPE 591 Introduction to Multimedia Networking
CPE 636 Integrated Services - Multimedia
CPE 645 Image Processing and Computer Vision
EE 612 Principles of Multimedia Compression

Information Systems

CPE 563 Networked Applications Engineering
CPE 591 Introduction to Multimedia Networking
CPE 636 Integrated Services - Multimedia
CPE 645 Image Processing and Computer Vision
NIS 584 Wireless Systems Security

Information Systems Security

CPE 591 Introduction to Multimedia Networking
CPE 668 Foundations of Cryptography
CPE 678 Information Networks I
CPE 691 Information Systems Security
EE 584 Wireless Systems Security

Intelligent Systems

CPE 645 Image Processing and Computer Vision
CPE 646 Pattern Recognition and Classification
EE 568 Software Defined Radio
EE 647 Analog and Digital Control Theory

Real-Time and Embedded Systems

Required:

CPE 555 Real-time and Embedded Systems
CPE 690 Introduction to VLSI Design

Choose two from the following list:

CPE 621 Analysis and Design of Real-Time systems
CPE 643 Logical Design of Digital Systems
CPE 645 Image Processing and Computer Vision

For further information on recommended elective courses under each concentration, refer to the Computer Engineering graduate program brochure, the ECE Web page, or consult with an academic advisor.

back to top

Master of Engineering - Networked Information Systems

In general, a bachelor's degree in electrical engineering or computer engineering (or a closely related discipline) with a minimum grade point average of 3.0 on a 4.0 scale is required for graduate study in Networked Information Systems. Outstanding applicants with degrees in other disciplines such as computer science, management, or mathematics may be admitted subject to demonstration of the technical background expected (perhaps with the requirement for completion of appropriate ramp courses or their equivalents with a grade of "B" or better). Such applicants, as well as applicants with significant career experiences but not satisfying the primary requirements, will be admitted on an individual basis depending on the student's background. Submission of GRE scores is recommended, but not required.

The master's degree requires completion of a total of 30 hours of credit. Each student must complete NIS 560 and two of the other five listed core courses and must complete the course requirements for one of the networked information systems concentrations. Elective courses are to be chosen from among the NIS, CPE, and EE numbered graduate courses in this catalog. Under special circumstances, an elective course not in the CPE, EE, or NIS numbered courses may be taken, with the approval of the student's academic advisor. A maximum of two elective courses not listed in the ECE program may be used for the master's degree with approval of the academic advisor.

Networked Information Systems Core Courses (three required)

NIS 560 Introduction to Networked Information Systems

And choose two of the following:

NIS 565 Management of Local Area Networks
NIS 591 Introduction to Multimedia Networking
NIS 654 Design and Analysis of Network Systems
NIS 678 Information Networks I
NIS 691 Information Systems Security

Networked Information Systems Concentrations:

Each student must complete a three-course concentration sequence appropriate for any one of the following concentration areas. Recommended courses are listed with each concentration. A course used as a core course cannot be used also to satisfy the requirement for three courses in a concentration. (Approval by the student's advisor is required to substitute another course for a listed course.)

back to top

Data Communications and Networks

NIS 611 Digital Communications Engineering I
NIS 653 Cross-Layer Design for Wireless Networks
NIS 654 Design and Analysis of Network Systems
NIS 655 Queuing Systems with Communications Applications I
NIS 678 Information Networks I

Information Networks

NIS 584 Wireless Systems Security
NIS 563 Networked Applications Engineering
NIS 654 Design and Analysis of Network Systems
NIS 678 Information Networks I
NIS 679 Information Networks II

Multimedia Information Systems

NIS 561 Database Management Systems I
NIS 583 Wireless Communications
NIS 591 Introduction to Multimedia Networking
NIS 636 Integrated Services - Multimedia
NIS 645 Image Processing and Computer Vision

Multimedia Technologies

NIS 582 Multimedia Network Security
NIS 612 Principles of Multimedia Compression
NIS 636 Integrated Services - Multimedia
NIS 645 Image Processing and Computer Vision

Networked Information Systems: Business Practices

NIS 630 Enterprise Systems Management
NIS 631 Management of Information Technology Organizations
NIS 632 Strategic Management of Information Technology
NIS 633 Integrating IS Technologies

Network Systems Technologies

NIS 586 Wireless Communications: Architectures, Protocols, and Standards

NIS 626 Optical Communication Systems
NIS 674 Satellite Communications

Secure Network Systems Design

NIS 560 Introduction to Networked Information Systems
NIS 584 Wireless Systems Security
NIS 592 Multimedia Network Security
NIS 654 Design and Analysis of Network Systems
NIS 691 Information Systems Security

For further information on recommended elective courses under each concentration, refer to the Networked Information Systems graduate program brochure, the ECE Web page, or consult with an academic advisor.

back to top

Degree of Electrical Engineer and Degree of Computer Engineer

These programs provide opportunities for the student to proceed with professional development beyond the master's level. The course work may be directed toward depth in the area of the master's degree or toward depth in a new area related to that of the master's degree. A design project of significance is required.

To be admitted to the Electrical Engineer or to the Computer Engineer program, the student must have a master's degree in electrical engineering or computer engineering with a minimum grade point average (GPA) of 3.0 on a 4.0 scale and the agreement of at least one regular faculty member in the department who expresses a willingness to serve as project advisor. Outstanding applicants with degrees in other disciplines may be admitted subject to demonstration of the technical background expected (perhaps with the requirement for completion of appropriate ramp courses or their equivalents with a grade of "B" or better). Such applicants, as well as applicants with significant career experiences but not satisfying the primary requirements, will be determined on an individual basis depending on the student's background.

At least 30 credits beyond the master's degree are required for the Engineer Degree. At least eight, but not more than fifteen, credits must be in the design project. The project courses for EE and CPE are EE 950 and CPE 950, respectively. An ECE faculty advisor and at least two faculty members must supervise the project; one must be a regular member of the faculty in the ECE department. A written report and oral presentation are required.

back to top

Doctoral Programs

Admission requirements to the Ph.D. program are naturally more stringent than those for the lesser degrees. More attention is paid to the student's background and potential to perform independent research. All applications are considered individually. In general, admissions are granted to students with a master's degree in electrical engineering or computer engineering who have achieved a minimum GPA of 3.5 on a 4.0 scale. Exceptional students may be accepted after receiving the bachelor's degree. Submission of GRE scores is recommended, but not required.

The Ph.D. degree requires 90 credits. A maximum of 30 credits can be applied toward the 90-credit requirement of the Ph.D. from a previous master's degree or from any other graduate courses subject to the approval of the advisor. All Ph.D. candidates must take at least 30 credits of thesis work and at least 20 credits of course work at Stevens beyond the master's degree. Courses counting towards the Ph.D. degree are expected to be taken from the ECE catalog courses (approval by the student's advisor is required to apply courses outside the ECE program to the Ph.D. degree).

All Ph.D. candidates must pass the written Ph.D. qualifying examination. Students may take the qualifying examination only twice. Failure to pass the qualifying examination in the second attempt will result in dismissal from the Ph.D. program.

After the student has successfully completed the qualifying examination, (s)he must arrange for an advisor to assist in the development of a thesis proposal. The advisor must be a full-time ECE professor or professor emeritus. Once a suitable topic has been found and agreed upon with the advisor, the student must prepare a thesis proposal. This thesis proposal should be completed and defended within one year of passing the Ph.D. qualifying examination. The proposal must indicate the direction that the thesis will take and procedures that will be used to initiate the research. Ordinarily, some preliminary results are included in the proposal. In addition, the proposal must indicate that the student is familiar with the research literature in his/her area. To this end, the proposal must include the results of a thorough literature search. A committee of at least three faculty members must accept the written thesis proposal. The committee chairperson is the thesis advisor. The other two members should be ECE department faculty. After the written proposal has been accepted, the examination committee conducts an oral defense. At this defense, the student presents his/her proposal.

All Ph.D. candidates who are working on a thesis must have a thesis committee chaired by the thesis advisor and consisting of at least four members. The thesis advisor and at least two other members must be full-time faculty members or professors emeritus of the ECE department. In addition, there must be one member who is a regular faculty member within another department at Stevens. It is permissible and desirable to have as a committee member a highly-qualified person from outside of Stevens. The committee must approve the completed thesis unanimously. After the thesis has been completed, it must be publicly defended.

back to top

Graduate Certificate Programs

The Department of Electrical and Computer Engineering offers several graduate certificate programs to students meeting the regular admission requirements for the master's program. Each Graduate Certificate is self-contained and highly focused, carrying 12 or more graduate credits. All of the courses may be used toward the master's degree, as well as for the graduate certificate.

Autonomous Robotics

Required:

CPE 521 Autonomous Mobile Robotic Systems
EE 631 Cooperating Autonomous Mobile Robots

Choose two from the following list with approval from an ECE advisor:

CPE 555 Real-Time and Embedded Systems
CPE 645 Image Processing and Computer Vision
EE 583 Wireless Communications
EE 621 Nonlinear Control

Digital Systems and VLSI Design

CPE 514 Computer Architecture
CPE 621 Analysis and Design of Real-Time Systems
CPE 643 Logical Design of Digital Systems I
CPE 644 Logical Design of Digital Systems II
CPE 690 Introduction to VLSI Systems Design

Real-Time and Embedded Systems

Required:

CPE 555 Real-Time and Embedded Systems
CPE 690 Introduction to VLSI Design

Choose two from the following list:

CPE 621 Analysis and Design of Real-Time systems
CPE 643 Logical Design of Digital Systems
CPE 645 Image Processing and Computer

Vision

Wireless Communications

EE 583 Wireless Communications (required)
(Select 3 of the following courses)
EE 584 Wireless Systems Security
EE 585 Physical Design of Wireless Systems
EE 586 Wireless Networking: Architectures, Protocols and Standards
EE 651 CDMA and Spread Spectrum
EE 653 Cross-Layer Design for Wireless Networks

back to top

Networked Information Systems

Required:

NIS 560 Introduction to Networked Information Systems

Select three of the following courses:

CPE 563 Networked Applications Engineering
EE 584 Wireless Systems Security
NIS 565 Management of Local Area Networks
NIS 591 Introduction to Multimedia Networking
NIS 678 Information Networks I
NIS 691 Information Systems Security

Secure Network Systems Design (Select 4 of the following courses)

CPE 560 Introduction to Networked Information
CPE 592 Multimedia Network Security
CPE 654 Design and Analysis of Network Systems
CPE 691 Information Systems Security
EE 584 Wireless Systems Security

Multimedia Technology

CPE 592 Multimedia Network Security
CPE 612 Principles of Multimedia Compression
CPE 636 Integrated Services - Multimedia
CPE 645 Image Processing and Computer Vision

Digital Signal Processing

EE 613 Digital Signal Processing for Communications
EE 616 Signal Detection and Estimation for Communications
EE 663 Digital Signal Processing I
EE 666 Multidimensional Signal Processing

Microelectronics and Photonics (Interdisciplinary)

MT/EE/PEP 507 Introduction to Microelectronics and Photonics, and three additional courses chosen from electives approved for this concentration.

For more information, see the concentration description earlier in the EE program description.

back to top

INTERDISCIPLINARY PROGRAMS

Integrated Product Development

The Integrated Product Development degree is an integrated Master of Engineering degree program. The core courses emphasize the design, manufacture, implementation, and life-cycle issues of engineering systems. The remaining courses provide a disciplinary focus. The program embraces and balances qualitative, as well as quantitative, aspects and utilizes state-of-the-art tools and methodologies. It aims to educate students in problem-solving methodologies, modeling, analysis, simulation, and technical management. The program trains engineers in relevant software applications and their productive deployment and integration in the workplace. For a detailed description of this program, please see the Interdisciplinary Programs section.

Electrical and Computer Engineering Track

The track in Electrical and Computer Engineering emphasizes the major themes intrinsic to design, manufacture, and implementation of electronic systems, as well as the transmission of signals and information in a digital format, emergent hardware principles, software integration, and data manipulation algorithms. Mathematical principles underlie all aspects of engineered systems, and a solid background in such principles is emphasized. Today's systems also reflect an integration of several means of manipulating signals, ranging from traditional analog filters to advanced digital signal processing techniques. The three courses that are common to Electrical and Computer Engineering emphasize the above. The remaining three courses can be either in Electrical Engineering, which emphasizes core principles guiding the design, manufacture, and implementation of today's diverse set of electronic systems, or in Computer Engineering, which provides a background in the principles and practices related to data/information systems design and implementation.

CPE 514 Computer Architectures
CPE 643 Logical Design of Digital Systems I
EE 585 Physical Design of Wireless Systems
EE 605 Probability and Stochastic Processes I
EE 602 Analytical Methods in Electrical Engineering
EE 603 Linear Systems Theory

EE 605 Probability and Stochastic Processes I

back to top

LABORATORIES

Laboratory facilities in the Department of Electrical and Computer Engineering are used for course-related teaching and special problems, design projects, and research. Students are exposed to a range of practical problems in laboratory assignments. Research laboratories are also heavily involved in both undergraduate and graduate education with special and dissertation projects. All research laboratories serve this dual-use function.

Center for Intelligent Networked Systems (iNetS)

A significant portion of the ECE research program is delivered through the Center for Intelligent Networked Systems (iNetS). INetS seeks to endow networked systems with the intelligence to provide a foundation for future networked systems to advance the objectives of performance, security, and interoperability.

The ECE Department also provides a number of thematic laboratories focusing on specific research topics. These laboratories, summarized below, support the broad themes of wireless systems, multimedia systems, information systems, and mobile platforms, such as autonomous robots.

Embedded Systems Laboratories

Embedded systems draw upon topics from electrical engineering, computer engineering, and computer science to create intelligent systems integrating principles of hardware/software co-design, analog/digital hardware co-design (mixed signal techniques), real-time operating systems, and programmable computational components (microprocessors, digital signal processors, etc.). The Embedded Systems and Robotics Lab and the Robotics and Automation Lab explore the design and realization principles of embedded systems, including extension to representative applications, such as autonomous robots.

Wireless Systems Laboratories

The Wireless Information Systems Engineering Lab, the Wireless Research Lab, and the Wireless Networks Lab highlight the design and engineering of advanced wireless systems, including cellular and PCS telephony, wireless LANs, satellite communications, and application-specific wireless links. Research includes the application of advanced signal processing algorithms and technologies to wireless communication systems. A major motivation of wireless communications is the elimination of a physical wire connected to the user's system. In the case of computer communications (e.g., LAN and modem capabilities), the transition to wireless connections allows the realization of true "any place" connectivity to data communications services.

Signal Processing in Communications Laboratories

Communication systems rely on extensive signal processing, in preparation for their transmission, to correct for distortions of the signal during transmission and to extract the original signal from the received signal. Digital signal processing is an important enabler of contemporary communication systems, providing the flexibility and reliability of computational algorithms to provide a wide variety of operations on signals. The Signal Processing in Communications Laboratories focus on advances in the underlying principles of signal processing and on the application of signal processing to contemporary communication systems.

Image Processing & Multimedia Laboratories

The high computing power and large data storage capabilities of contemporary computer systems, along with the high data rates of today's networks, have made practical many sophisticated techniques used for 2- and 3-dimensional images and video. The Visual Information Environments Lab highlight advances in the underlying image processing and computer vision algorithms that serve as foundations for a wide range of applications. Related to these visual environments is the general area of multimedia, combining visual, audio and other sensory information within an integrated framework. The Multimedia Systems Networking and Communications Lab expxlores the several issues related to reliable and secure communications of multimedia information across networks. Themes related to secure information are also explored.

Secure Network Systems Design Laboratory

Today's extensive use of electronic information systems (including data networks, data storage systems, digital computers, etc.) has revolutionized both commercial and personal access to information and exchange of information. However, serious issues appear in the security of information, assurance of the end user's identity, protection of the information system, etc. The Secure Network Systems Design Laboratory provides both physical testbeds and computer systems/resources for exploration of this broad issue.

back to top

UNDERGRADUATE COURSES

Electrical Engineering

E 245 Circuits and Systems
(2-3-3)

Ideal circuit elements, Kirchoff laws and nodal analysis, source transformations, Thevenin/Norton theorems, operational amplifiers, response of RC, RL, and RLC circuits, sinusoidal sources and steady state analysis, analysis in the frequency domain, average and RMS power, linear and ideal transformers, linear models for transistors and diodes, analysis in the s-domain, Laplace transforms, and transfer functions. Prerequisite: PEP 102 or PEP 112. Corequisite: MA 221.

E 246 Electronics and Instrumentation
(3-0-3)
Signal acquisition procedures; instrumentation components; electronic amplifiers; signal conditioning; low-pass, high-pass and band-pass filters; A/D converters and antialiasing filters; embedded control and instrumentation; microcontrollers; digital and analog I/O; instruments for measuring physical quantities such as motion, force, torque, temperature, pressure, etc.; FFT and elements of modern spectral analysis; random signals; and standard deviation and bias. Prerequisite: E 245.

EE 250 Mathematics for Electrical Engineers
(3-0-3)
Introduction to logic, methods of proof, proof by induction, and the pigeonhole principle with applications to logic design. Analytic functions of a complex variable, Cauchy-Riemann equations, and Taylor series. Integration in the complex plane, Cauchy Integral formula, Liouville's theorem, maximum modulus theorem. Laurent series, residues, and the residue theorem. Applications to system theory, Laplace transforms, and transmission lines. Prerequisite: MA 221.

EE 291 Supplemental Topics in Circuits and Systems
(1-0-1)
Additional work for transfer students to cover topics omitted from Circuits and Systems courses taken elsewhere. This additional work is usually specified as completion of particular PSI modules. A grade of pass/fail is assigned for this course, and students who pass receive full transfer of credit for the appropriate course. Failures are noted on the student's record and the student is required to enroll in the full course at Stevens.

EE 322 Engineering Design VI
(1-3-2)
This course addresses the general topic of selection, evaluation, and design of a project concept, emphasizing the principles of team-based projects and the stages of project development. Techniques to acquire information related to the state-of-the-art concepts and components impacting the project, evaluation of alternative approaches, and selection of viable solutions based on appropriate cost factors, presentation of proposed projects at initial, intermediate, and final stages of development, and related design topics. Students are encouraged to use this experience to prepare for the senior design project courses. Corequisite: EE 345.

EE 345 Modeling and Simulation
(3-0-3)

Development of deterministic and non-deterministic models for physical systems, engineering applications, and simulation tools for deterministic and non-deterministic systems. Case studies and projects.

EE 348 System Theory
(3-0-3)
An introduction to the mathematical methods used in the study of communications systems with practical applications. Discrete and fast Fourier transforms. Functions of a complex variable. Laplace and Z transforms. Prerequisites: E 245, EE 250.

EE 359 Electronic Circuits
(3-0-3)
Design of differential amplifiers using BJTs or FETs, design of output stages (class B and class AB), output and input impedance of differential amplifiers, and frequency response. Feedback amplifiers, Nyquist criteria, Nyquist plots and root loci, bode plots, gain/phase margins and application in compensation for operational amplifiers, oscillators, tuned amplifiers, and filters (passive and active). A suitable circuit analysis package is used for solving many of the problems. Prerequisite: E 232.

EE 423 Engineering Design VII
(0-8-3)
Senior design course. The development of design skills and engineering judgment, based upon previous and current course and laboratory experience, is accomplished by participation in a design project. Projects are selected in areas of current interest, such as communication and control systems, signal processing, and hardware and software design for computer-based systems. To be taken during the student's last fall semester as an undergraduate student. It includes the two-credit core module on E 421 Entrepreneurial Analysis of Engineering Design during the first semester.

EE 424 Engineering Design VIII
(0-8-3)
A continuation of EE 423 in which the design is implemented and demonstrated. This includes the completion of a prototype (hardware and/or software), testing and demonstrating performance, and evaluating the results. To be taken during the student's last spring semester as an undergraduate student. Prerequisite: EE 423.

EE 440 Current Topics in Electrical and Computer Engineering
(3-0-3)
This course consists of lectures designed to explore a topic of contemporary interest from the perspective of current research and development. In addition to lectures by the instructors and discussions led by students, the course includes talks by professionals working in the topic being studied. When appropriate,

team-based design projects are included. Cross-listed with CPE 440.

EE 441 Introduction to Wireless Systems (3-0-3)
Review of history, concepts, and technologies of wireless communications; explanations and mathematical models for analyzing and designing wireless systems; description of various wireless systems, including cellular systems, wireless local area networks, and satellite-based communication systems; and wireless design projects using Matlab, LabView, and software-defined radio. Prerequisite: EE 423. Cross-listed with CPE 441.

EE 448 Digital Signal Processing (3-0-3)
Introduction to the theory and design of digital signal processing systems. Include sampling, linear convolution, impulse response, and difference equations; discrete-time Fourier transform, DFT/FFT, circular convolution, and Z-transform; frequency response, magnitude, phase, and group delays; ideal filters, linear-phase FIR filters, all-pass filters, minimum-phase, and inverse systems; and digital processing of continuous-time signals. Prerequisite: EE 348.

EE 465 Introduction to Communication Systems (3-0-3)
Review of probability, random processes, signals, and systems; continuous-wave modulation, including AM, DSB-SC, SSB, FM, and PM; superheterodyne receiver; noise analysis; pulse modulation including PAM, PPM, PDM, and PCM; quantization and coding; delta modulation, linear prediction, and DPCM; baseband digital transmission, matched filter and error rate analysis; and passband digital transmission including ASK, PSK, and FSK. Prerequisites: E 243 and EE 348.

EE 471 Transport Phenomena in Solid State Devices (4-0-4)
Introduction to the underlying phenomena and operation of solid state electronic, magnetic, and optical devices essential in the functioning of computers, communications, and other systems currently being designed by engineers and scientists. Charge carrier concentrations and their transport are analyzed from both microscopic and macroscopic viewpoints, carrier drift due to electric and magnetic fields in solid state devices is formulated, and optical energy absorption and emission are related to the energy levels in solid-state materials. Diffusion, generation, and recombination of charge carriers are combined with carrier drift to produce a continuity equation for the analysis of solid-state devices. Explanations and models of the operation of PN, metal-oxide, metal-oxide-semiconductor, and heterostructure junctions are used to describe diode, transistor,

photodiode, laser, integrated circuit, and other device operation. Prerequisite: E 232.

EE 473 Electromagnetic Fields
(3-0-3)
Introduction to electromagnetic fields and applications. Vector calculus: orthogonal coordinates, gradient, divergence, curl, and Stokes' and divergence theorems. Electrostatics: charge, Coulomb's and Gauss' laws, potential, conductors and dielectrics, dipole fields, stored energy and power dissipation, resistance and capacitance, polarization, boundary conditions, and LaPlace's and Poisson's equations. Magnetostatics: Biot-Savart's and Ampere's laws, scalar and vector potentials, polarization, magnetic materials, stored energy, boundary conditions, inductance, magnetic circuits, and force. Time-dependent Maxwell's equations: displacement current, constitutive relations, isotropic and anisotropic media, force, boundary conditions, and the time-dependent Poynting vector and power. Circuit theory of transmission lines, transient response, and multiple reflections. Prerequisite: MA 227.

EE 474 Microwave Systems
(3-0-3)
Complex scalars and vectors, sinusoidal steady-state, complex Maxwell's equations, and complex Poynting's theorem. Propagation of plane waves: complex vector wave equation, loss-less transmission line analogy, sinusoidal steady-state, frequency, wavelength and velocity, polarity, lossy media, radiation pressure, group velocity, and reflection and refraction. Snell's law, Brewster angle, field theory of transmission lines, TEM waves, sinusoidal steady-state transmission line theory, traveling and standing waves, Smith Chart, matching power flow, lossy lines, and circuit and field theory. Waveguides: TE and TM modes in general guides, propagation constant and wave impedance, separation of variables, rectangular and cylindrical guides, representation of wavelength fields by plane wave components, propagation and cutoff (evanescent) modes, the Poynting vector, dielectric guides, and losses. Waveguide resonators. Antennas: scalar and vector potentials, wave equations, spherical coordinates, electric and magnetic dipole antennas, and aperture antennas. Microwave electronics and traveling wave tubes. Prerequisite: EE 473.

EE 475 Advanced Communication Systems
(3-0-3)
Information theory and coding. Error control coding: CRCs, trellis codes, convolutional codes, and Viterbi decoding. Quantization and digitization of speech: PCM, ADPCM, DM, LPC, and VSELP algorithms. Carrier recovery and synchronization. Multiplexers: TDM and FDM hierarchies. Echo cancelers, equalizers, and scrambler/unscramblers. Spread spectrum communication systems. Mobile communications: digital

cellular communication systems and PCS Encryption techniques. Introduction to computer communications networks. Prerequisite: EE 465.

EE 478 Control Systems
(3-0-3)
Introduction to the theory and design of linear feedback and control systems in both digital and analog form, review of z-transform and Laplace transforms, time domain performance error of feedback systems, PID controller, frequency domain stability, including Nyquist stability in both analog and digital form, frequency domain performance criteria and design, such as via the gain and phase plots, state variable analysis of linear dynamical systems, elementary concepts of controllability, observability and stability via state space methods, and pole placement and elements of state variable design for single-input single-output systems. Prerequisite: EE 348.

EE 480 Optical Fiber Communication Systems
(3-0-3)
Relevant characteristics of optical fibers, sources (LED and laser diodes), and photodetectors (PIN, APD) are introduced to provide the background for optical fiber communication system design. Subsystems design deals with optical transmitters, optical receivers, and optical components (switches, couplers, multiplexers, and demultiplexers). Optical fiber systems design and applications include long-haul optical transmission systems, local area networks, coherent optical communication, and future trends. Prerequisite: EE 473.

EE 485-486 Research in Electrical Engineering I-II
(0-8-3) (0-8-3)
Individual investigation of a substantive character taken at the undergraduate level under the guidance of a faculty advisor leading to a thesis with a public defense. The student's thesis committee consists of the faculty advisor and one or more readers. Prior approval from the faculty advisor and the Department Director is required. Hours to be arranged with the faculty advisor. For information regarding a Degree with Thesis, see the "Academic Procedures, Requirements, and Advanced Degrees" section of this catalog.

back to top

Computer Engineering

CPE 322 Engineering Design VI
(1-3-2)
This course addresses the general topic of selection, evaluation, and design of a project concept, emphasizing the principles of team-based projects and the stages of project development. Techniques to acquire information related to the state-of-the-art concepts and components impacting the project, evaluation of alternative approaches, and selection of viable solutions based on appropriate cost factors,

presentation of proposed projects at initial, intermediate, and final stages of development and related design topics. Students are encouraged to use this experience to prepare for senior design project courses. Corequisite: CPE 345.

CPE 345 Modeling and Simulation
(3-0-3)
Development of deterministic and non-deterministic models for physical systems, engineering applications, and simulation tools for deterministic and non-deterministic systems. Case studies and projects. Corequisite: CPE 322.

CPE 358 Switching Theory and Logical Design
(3-0-3)
Digital systems, number systems and codes, Boolean algebra, application of Boolean algebra to switching circuits, minimization of Boolean functions using algebraic, Karnaugh map and tabular methods, design of combinational circuits, programmable logic devices, sequential circuit components, and design and analysis of synchronous and asynchronous sequential circuits.

CPE 360 Computational Data Structures and Algorithms
(3-0-3)
The role of data structures and algorithms in the real world; principles of programming, including the topics of control flow, recursion, and I/O; principles of computational intelligence; topics from elementary data structures, including arrays, lists, stacks, queues, pointers, and strings; searching and sorting; data structures for concurrent execution; topics from elementary algorithms, including analysis of algorithms and efficiency, computational complexity, empirical measurements of computational complexity of algorithms, and proof techniques, including induction; selected topics from advanced algorithms including distributed algorithms; and programming laboratory exercises and projects.

CPE 390 Microprocessor Systems
(3-3-4)
A study of the implementation of digital systems using microprocessors. The architecture and operation of microprocessors is examined in detail, along with I/O interfacing, interrupts, DMA, and software design techniques. Specialized controller chips for interrupts, DMA, arithmetic processing, graphics, and communications are discussed. The laboratory component introduces hardware and software design of digital systems using microprocessors. Design experiments include topics such as bus interfacing, memory decoding, serial communications, and programmable ports. Prerequisite: CPE 358.

CPE 423 Engineering Design VII
(0-8-3)
Senior design course. The development of design skills

and engineering judgment, based upon previous and current course and laboratory experience, is accomplished by participation in a design project. Projects are selected in areas of current interest, such as communication and control systems, signal processing, and hardware and software design for computer-based systems. To be taken during the student's last fall semester as an undergraduate student. It includes the two-credit core module on Entrepreneurial Analysis of Engineering Design (E 421) during the first semester.

CPE 424 Engineering Design VIII
(0-8-3)
A continuation of CPE 423 in which the design is implemented and demonstrated. This includes the completion of a prototype (hardware and/or software), testing and demonstrating performance, and evaluating the results. To be taken during the student's last spring semester as an undergraduate student. Prerequisite: CPE 423.

CPE 437 Interactive Computer Graphics
(3-0-3)
Introduction to computer graphics. Designing a complete 2-D graphics package with an interface. Graphics hardware overview. Drawing of 2-D primitives (polylines, polygons, and ellipses). Character generation. Attribute primitives (line styles, color and intensity, area filling, and character attributes). 2D transformations (translation, general scaling, general rotation, shear, reflection). Windowing and clipping. 3-D concepts (3-D transformations, 3-D viewing, and 3-D modeling). Selected topics. Cross-listed with CS 437. Prerequisite: CS 385.

CPE 440 Current Topics in Electrical and Computer Engineering
(3-0-3)
This course consists of lectures designed to explore a topic of contemporary interest from the perspective of current research and development. In addition to lectures by the instructors and discussions led by students, the course includes talks by professionals working in the topic being studied. When appropriate, team-based design projects are included. Cross-listed with EE 440.

CPE 441 Introduction to Wireless Systems
(3-0-3)
Review of history, concepts, and technologies of wireless communications; explanations and mathematical models for analyzing and designing wireless systems; description of various wireless systems, including cellular systems, wireless local area networks, and satellite-based communication systems; and wireless design projects using Matlab, LabView, and software-defined radio. Prerequisite: CPE 423. Cross-listed with EE 441.

CPE 442 Database Management Systems (3-0-3)
Introduction to the basic principles of relational database systems, their structure, and use. Topics include the use of the entity-relationship model in specifying a database, the relational model, and the translation of entity-relationship graphs into relations, relational algebra, relational calculus, equivalence among relational query languages, SQL, integrity constraints, and relational database design (normal forms). Cross-listed with CS 442. Prerequisite: CS 385.

CPE 450 Embedded Systems for Real-Time Applications (3-0-3)
Unlike typical software-based systems, real-time systems must complete their tasks within specified timeframes. Unlike general purpose computing platforms, embedded systems must perform their tasks while minimizing tight resource constraints. This course addresses the considerations in designing real-time embedded systems, both from a hardware and software perspective. The primary emphasis is on real-time processing for communications and signal processing systems, but applications to seismic and environmental monitoring, process control, and biomedical systems will be addressed. Programming projects in a high level language like C/C++ will be an essential component of the course, as well as hardware design with modern design tools. Prerequisites: Familiarity with C/C++, probability and random variables, system theory, switching theory, and logical design.

CPE 462 Introduction to Image Processing and Coding (3-0-3)
This course introduces the basics of signal and image processing. Topics include: digital signal processing fundamentals; 2-D signal filtering and transforms; image perception, formation, sampling, and color representations; image smoothing and sharpening, and histogram equalization; image analysis, edge detection, thresholding, and segmentation; geometric image processing; digital halftoning; introduction to information theory, Huffman coding, and image and video compression standards such as JPEG and MPEG.

CPE 485-486 Research in Computer Engineering III-IV (0-8-3) (0-8-3)
Individual investigation of a substantive character taken at the undergraduate level under the guidance of a faculty advisor leading to a thesis with a public defense. The student's thesis committee consists of the faculty advisor and one or more readers. Prior approval from the faculty advisor and the Department Director is required. Hours to be arranged with the faculty advisor. For information regarding a Degree with Thesis, see the "Academic Procedures, Requirements, and Advanced

Degrees" section of this catalog.

CPE 487 Digital System Design
(3-0-3)
Design of complex digital CMOS/VLSI circuits. Introduction to MOS transistor characteristics and fabrication, digital circuit design and layout for integrated circuits, major categories of VLSI circuit functions, design methodologies, including use of Hardware Description Languages (HDL), FPGA, verification, simulation, and testability. The course includes a project using VHDL for the design of a significant system function. Prerequisite: CPE 358.

CPE 488 Computer Architecture
(3-0-3)
The design and evaluation of modern computer architecture. Topics covered include analytic models for computer system evaluation, memory design, including a study of cache memories and support for virtual memory, pipelined systems, RISC architectures, vector computers and parallel and distributed architectures. Cross-listed with CS 488. Prerequisites: CPE 390, E 243.

CPE 490 Information Systems Engineering I
(3-0-3)
The focus of the course is on data networks and end-user software environments for information systems. Topics include the TCP/IP protocols, organization of large-scale data networks, end-to-end operation over heterogeneous networks, and the software foundation of client-server application programs. The students complete a project using TCP/IP protocols to create a basic client-server application.

CPE 491 Information Systems Engineering II
(3-0-3)
This course emphasizes a major component of contemporary networked information systems, namely visually rich information, including multimedia, virtual reality, human-machine interactions, and related topics. The students complete a project in which they demonstrate competency in creating and manipulating the information and the resources used to store, transfer, and present the information.

CPE 493 Data and Computer Communications
(3-0-3)
Introduction to information networks, data transmission and encoding, digital communication techniques, circuit switching and packet switching, OSI protocols, switched networks and LANs, introduction to ISDN and ATM/SONET networks, and system architectures. Prerequisite: E 243.

CPE 494 Networked Systems Design: Principles and Practices
(3-0-3)
Basic elements in local and wide-area network infrastructures, architecture, and protocols at all layers;

client-server systems programming using sockets and remote procedure cells; concurrency and coordination issues and techniques; concepts and tools for fault tolerance, failure detection, checkpointing, disaster recovery, and rejuvenation in networked applications; and overview of network systems middleware facilities, such as .NET and Weblogic to illustrate the above principles and techniques. Prerequisite: Familiarity with C/C++.

back to top

GRADUATE COURSES

All Graduate courses are 3 credits except where noted.

Electrical Engineering

EE 503 Introduction to Solid State Physics
Description of simple physical models which account for electrical conductivity and thermal properties of solids. Basic crystal lattice structure, X-ray diffraction, and dispersion curves for phonons and electrons in reciprocal space. Energy bands, Fermi surfaces, metals, insulators and semiconductors, superconductivity, and ferromagnetism. Cross-listed with PEP 503 and MT 503.

EE 507 Introduction to Microelectronics and Photonics
An overview of microelectronics and photonics science and technology. It provides students who wish to specialize in his/her application, physics or fabrication with the necessary knowledge of how the different aspects are interrelated. It is taught in three modules: design and applications, taught by EE faculty; operation of electronic and photonic devices, taught by Physics faculty; and fabrication and reliability, taught by the materials faculty. Cross-listed with PEP 507 and MT 507.

EE 509 Intermediate Waves and Optics
The general study of field phenomena; scattering and vector fields and waves; dispersion, phase, and group velocity; interference, diffraction, and polarization; coherence and correlation; and geometric and physical optics. Cross-listed with PEP 509.

EE 510 Introduction to Radar Systems
The radar equation for pulses, signal to noise ratio, target cross section, and antenna parameters; Doppler radar, CW radar, multifrequency CW radar, FM radar, and chirp radar; tracking and acquisition radar, radar wave propagation; transmitter and receiver design;and interference considerations.

EE 515-516 Photonics I, II
This course will cover topics encompassing the fundamental subject matter for the design of optical systems. Topics will include optical system analysis, optical instrument analysis, applications of thin-film coatings, and opto-mechanical system design in the first

term. The second term will cover the subjects of photometry and radiometry, spectrographic and spectrophotometric systems, infrared radiation measurement and instrumentation, lasers in optical systems, and photon-electron conversion. Prerequisite: PEP 209 or PEP 509. Cross-listed with PEP 515-516 and MT 515-516.

EE 541 Physics of Gas Discharges
Charged particle motion in electric and magnetic fields; electron and ion emission; ion-surface interaction; electrical breakdown in gases; dark discharges and DC glow discharges; confined discharge; AC, RF, and microwave discharges; arc discharges, sparks, and corona discharges; non-thermal gas discharges at atmospheric pressure; and discharge and low-temperature plasma generation. Typical texts: J.R. Roth, *Industrial Plasma Engineering: Principles, Vol. 1* and Y.P. Raizer, *Gas discharge Physics*. Cross-listed with PEP 541.

EE 542 Electromagnetism
Electrostatics; Coulomb-Gauss law; Poisson-Laplace equations; boundary value problems; image techniques, and dielectric media; magnetostatics; multipole expansion, electromagnetic energy, electromagnetic induction, Maxwell's equations, electromagnetic waves, waves in bounded regions, wave equations and retarded solutions, simple dipole antenna radiation theory, and transformation law of electromagnetic fields. Spring semester. Typical text: Reitz, Milford and Christy, *Foundation of Electromagnetic Theory*. Cross-listed with PEP 542.

EE 561 Solid State Electronics for Engineering I
This course introduces fundamentals of semiconductors and basic building blocks of semiconductor devices that are necessary for understanding semiconductor device operations. It is for first-year graduate students and upper-class undergraduate students in electrical engineering, applied physics, engineering physics, optical engineering, and materials engineering who have no previous exposure to solid state physics and semiconductor devices. Topics covered will include description of crystal structures and bonding; introduction to statistical description of electron gas; free-electron theory of metals; motion of electrons in periodic lattice-energy bands; Fermi levels; semiconductors and insulators; electrons and holes in semiconductors; impurity effects; generation and recombination; mobility and other electrical properties of semiconductors; thermal and optical properties; p-n junctions; and metal-semiconductor contacts. Cross-listed with PEP 561 and MT 561.

EE 562 Solid State Electronics for Engineering II
This course introduces operating principles and develops models of modern semiconductor devices that are useful in the analysis and design of integrated circuits. Topics covered include: charge carrier transport in

semiconductors; diffusion and drift; injection and lifetime; p-n junction devices; bipolar junction transistors; metal-oxide-semiconductor field effect transistors and high electron mobility transistors; microwave devices; light-emitting diodes, semiconductor lasers, and photodetectors; and integrated devices. Cross-listed with PEP 562 and MT 562.

EE 568 Software-Defined Radio
This course offers an introduction to software-defined radios, devices that can be programmed to work with a variety of different radios. The course covers the following topics: software radio architectures, existing software radio efforts, a review of basic receiver design principles, and application to software radios. Basic questions, design tradeoffs, and architectural issues are also discussed. Several case studies of software radios will be discussed throughout the course.

EE 583 Wireless Communications
An overview of the main themes impacting wireless communication systems. Recent, present, and future generation wireless systems; cell-based systems; TDMA, FDMA, and CDMA approaches for wireless; mobile communications and system control; wireless LANs; wireless channels (multipath, fading, Doppler shifts, etc.); signal transmission in various physical environments (urban, rural, and building); 3G digital wireless systems; principles of receiver and transmitter architectures; interference and noise effects; digital signal processing in wireless systems; and contrasts between wireless and wireline communications for major applications. Cross-listed with NIS 583.

EE 584 Wireless Systems Security
Wireless systems and their unique vulnerabilities to attack; system security issues in the context of wireless systems, including satellite, terrestrial microwave, military tactical communications, public safety, cellular, and wireless LAN networks; and security topics: confidentiality/privacy, integrity, availability, and control of fraudulent usage of networks. Issues addressed include jamming, interception, and means to avoid them. Case studies and student projects are important components of the course. Cross-listed with NIS 584 and TM 684.

EE 585 Physical Design of Wireless Systems
Physical design of wireless communication systems, emphasizing present and next generation architectures. Impact of non-linear components on performance; noise sources and effects; interference; optimization of receiver and transmitter architectures; individual components (LNAs, power amplifiers, mixers, filters, VCOs, phase-locked loops, frequency synthesizers, etc.); digital signal processing for adaptable architectures; analog-digital converters; new component technologies (SiGe, MEMS, etc.); specifications of component performance; reconfigurability and the role

of digital signal processing in future generation architectures; direct conversion; RF packaging; and minimization of power dissipation in receivers. Cross-listed with PEP 585 and MT 585.

EE 586 Wireless Networking: Architectures, Protocols, and Standards
This course addresses the fundamentals of wireless networking, including architectures, protocols, and standards. It describes concepts, technology, and applications of wireless networking as used in current and next-generation wireless networks. It explains the engineering aspects of network functions and designs. Issues such as mobility management, wireless enterprise networks, GSM, network signaling, WAP, mobile IP, and 3G systems are covered. Cross-listed with NIS 586 and TM 586.

EE 587 Microwave Engineering I
A study of microwave techniques at both the component and system level. Topics include wave propagation and transmission, uniform and non-uniform transmission lines, rectangular and circular waveguide, losses, microstrip, waveguide excitation, modal expansion of waveguide fields, perturbation theory, ferrites, scattering parameters for lumped and distributed systems, general theory of microwave junctions waveguide components including tee's, circulators, isolators, phase shifters, splitters, and directional couplers. Prerequisite: EE 542 or equivalent.

EE 588 Microwave Engineering II
A more advanced treatment of microwave systems. Topics include coupled mode theory, periodic structures, cavities, cavity excitation and perturbation, circuit representations, broadband matching, microwave filter theory, antenna theory, including various types of wire antennas, horns, dishes, antenna arrays, phased arrays, sources, detectors, modulators, limiters, optical-microwave interaction, and microwave signal processing. Topics may vary to accommodate specific interests. Prerequisite: EE 587.

EE 595 Reliability and Failure of Solid State Devices
This course deals with the electrical, chemical, environmental, and mechanical driving forces that compromise the integrity and lead to the failure of electronic materials and devices. Both chip and packaging level failures will be modeled physically and quantified statistically in terms of standard reliability mathematics. On the packaging level, thermal stresses, solder creep, fatigue and fracture, contact relaxation, corrosion, and environmental degradation will be treated. Prerequisite: EE 507. Cross-listed with MT 595 and PEP 595.

EE 596 Micro-Fabrication Techniques
Deals with aspects of the technology of processing procedures involved in the fabrication of microelectronic

devices, and microelectromechanical systems (MEMS). Students will become familiar with various fabrication techniques used for discrete devices as well as large-scale integrated thin-film circuits. Students will also learn that MEMS are sensors and actuators that are designed using different areas of engineering disciplines and they are constructed using a microlithographically-based manufacturing process in conjunction with both semiconductor and micromachining microfabrication technologies. Prerequisite: EE 507. Cross-listed with MT 596 and PEP 596.

EE 602 Analytical Methods in Electrical Engineering
The theory of linear algebra with application to state space analysis. Topics include Cauchy-Binet and Laplace determinant theorems, and system of linear equations; linear transformations, basis, and rank; Gaussian elimination; LU and congruent transformations; Gramm-Schmidt; eigenvalues, eigenvectors, and similarity transformations; canonical forms; functions of matrices; singular value decomposition; generalized inverses; norm of a matrix; polynomial matrices; matrix differential equations; state space; and controllability and observability.

EE 603 Linear System Theory
Fourier transforms; distribution theory; Gibbs phenomena; Shannon sampling; Poisson sums; discrete and fast Fourier transforms; Laplace transforms; z-transforms; the uncertainty principle; Hilbert transforms; computation of inverse transforms by contour integration; and stability and realization theory of linear, time invariant, continuous, and discrete systems.

EE 605 Probability and Stochastic Processes I
Axioms of probability. Discrete and continuous random variables. Functions of random variables. Expectations. Moments, characteristic functions, and moment-generating functions. Inequalities, convergence concepts, and limit theorems. Central limit theorem. Characterization of simple stochastic processes. Cross-listed with NIS 605.

EE 606 Probability and Stochastic Processes II
Introduction and review of probability as a measure, measure theoretic notions of random variables and stochastic processes, discrete time and continuous time Markov chains, renewal processes, delayed renewal processes, convergence of random sequences, martingale processes, stationarity, and ergodicity. Applications of these topics with examples from networked communications, wireless communications, statistical signal processing, and game theory. Prerequisite: EE 605.

EE 609 Communication Theory
Review of probability theory with applications to digital

communications, digital modulation techniques, receiver design, bit error rate calculations, bandwidth efficiency calculations, convolutional encoding, bandwidth efficient coded modulation, wireless fading channel models, and shannon capacity, software simulation of communication systems.

EE 610 Error Control Coding for Networks
Error-control mechanisms; elements of algebra; linear block codes; linear cyclic codes; fundamentals of convolutional codes; Viterbi decoding codes in mobile communications; Trellis-coded modulation; concatenated coding systems and turbo codes; BCH codes; Reed-Solomon codes; implementation architectures and applications of RS codes; and ARQ and interleaving techniques.

EE 611 Digital Communications Engineering
Waveform characterization and modeling of speech/image sources; quantization of signals; uniform and nonuniform adaptive quantization; pulse code modulation (PCM) systems; differential PCM (DPCM); linear prediction theory; delta modulation and sigma-delta modulation systems; subband coding with emphasis on speech and audio coding; and data compression methods, such as Huffman coding, Ziv-Lempel coding, and arithmetic coding. Cross-listed with NIS 611.

EE 612 Principles of Multimedia Compression
Brief introduction to Information Theory; entropy and rate; Kraft-McMillan inequality; entropy codes - Huffman and arithmetic codes; scalar quantization-quantizer design issues, the Lloyd quantizer, and the Lloyd-Max quantizer; vector quantization - LBG algorithm and other quantizer design algorithms; structured VQs; entropy constrained quantization; bit allocation techniques: generalized BFOS algorithm; brief overview of linear algebra; transform coding: KLT, DCT, and LOT; subband coding; wavelets; wavelet based compression algorithms (third generation image compression schemes)- EZW algorithm, the SPIHT algorithm, and the EBCOT algorithm; video compression: motion estimation and compensation; image and video coding standards: JPEG/JPEG 2000, MPEG, H.263, and H.263+; source coding and error resilience. Cross-listed with NIS 612.

EE 613 Digital Signal Processing for Communications
This course teaches digital signal processing techniques for wireless communications. It consists of two parts. Part 1 covers basic DSP fundamentals, such as DFT, FFT, IIR and FIR filters, and DSP algorithms (ZF, ML, and MMSE). Part 2 covers DSP applications in wireless communications. Various physical layer issues in wireless communications are addressed, including channel estimation, adaptive equalization, synchronization, interference cancellation, OFDM, multi-user detection and rake receiver in CDMA, space-time coding, and smart antennae.

EE 615 Multicarrier Communications
This course reviews multicarrier modulation (MCM) methods which offer several advantages over conventional single carrier systems for broadband data transmission. Topics include fundamentals of MCM, where the data stream is divided into several parallel bit streams, each of which has a much lower bit rate, to exploit multipath diversity and practical applications. It will cover new advances, as well as the present core technology. Hands-on learning with computer-based approaches will include simulation in MATLAB and state-of-the-art high level software packages to design and implement modulation, filtering, synchronization, and demodulation. Corequisite: EE 609 or equivalent.

EE 616 Signal Detection and Estimation for Communications
Introduction to signal detection and estimation principles with applications in wireless communication systems. Topics include optimum signal detection rules for simple and composite hypothesis tests, Chernoff bound and asymptotic relative efficiency, sequential detection, and nonparametric detection; and optimum estimation, including Bayesian estimation and maximum likelihood, Fisher information and Cramer-Rao bound, linear estimation, least squares, and weight least squares.

EE 617 Statistical Signal Processing
Mathematical modeling of signal processing; Wiener-Kalman filters, LP, and LMS methods; estimation and detection covering minimum-variance-unbiased (MVUB) and maximum likelihood (ML) estimators, Cramer-Rao bound, Bayes and Neyman-Pearson detectors, and CFAR detectors; methods of least squares (LS): batch mode, weighted LS, total LS (TLS), and recursive LS (RLS); SVD and high resolution spectral estimation methods including MUSIC, modified FBLP, and Min-Norm; higher order spectral analysis (HOSA) with applications of current interest; PDA and JPDA data association trackers with MultiDATTM; and applied computer projects on major topics. Corequisite: EE 616.

EE 619 Solid State Devices
Operating principle, modeling, and fabrication of solid state devices for modern optical and electronic system implementation; recent developments in solid state devices and integrated circuits; devices covered include bipolar and MOS diodes and transistors, MESFET, MOSFET transistors, tunnel, IMPATT and BARITT diodes, transferred electron devices, light emitting diodes, semiconductor injection and quantum-well lasers, PIN, and avalanche photodetectors. Prerequisite: EE 503 or equivalent. Cross-listed with PEP 619.

EE 620 Reliability Engineering
Combinatorial reliability including series, parallel, cascade, and multistage networks; Markov, Weibull, and

exponential failure models; redundancy; repairability; marginal and catastrophic failures; and parameter estimation. Prerequisite: EE 605.

EE 621 Nonlinear Control
Methods for analysis and design of nonlinear control systems emphasizing Lyapunov theory. Second order systems, phase plane descriptions of ononlinerar phenomena, limit cycles, stability, direct and indirect method of Lyapunov, linearization, feedback linearization, Lyapunov-based design, and backstepping. Prerequisite: EE 478 Fundamentals of Control or equivalent.

EE 626 Optical Communication Systems
Components for and design of optical communication systems; propagation of optical signals in single mode and multimode optical fibers; optical sources and photodetectors; optical modulators and multiplexers; optical communication systems: coherent modulators, optical fiber amplifiers, and repeaters; transcontinental and transoceanic optical telecommunication system design; and optical fiber LANs. Cross-listed with PEP 626, MT 626, and NIS 626.

EE 627-628 Data Acquisition and Processing III, IV
The application of electronic principles and analog and digital integrated circuits to the design of industrial and scientific instrumentation, process control, and robotics and automation. Topics include sensors and transducers, analog and digital signal conditioning and processing, data conversion, data transmission and interface standards, machine vision, control, and display. Microcomputers, microprocessors, and their support components are applied as system elements. Prerequisite: EE 603.

EE 631 Cooperating Autonomous Mobile Robots
Advanced topics in autonomous and intelligent mobile robots, with emphasis on planning algorithms and cooperative control. Robot kinematics, path and motion planning, formation strategies, cooperative rules, and behaviors. The application of cooperative control spans from natural phenomena of groupings, such as fish schools, bird flocks, and deer herds, to engineering systems such as mobile sensing networks and vehicle platoon. Prerequisites: CPE 521 Autonomous Mobile Robotic Systems is recommended. A familiarity with matrix algebra, differential equations, and feedback control will be helpful.

EE 647 Analog and Digital Control Theory
State space description of linear dynamical systems; canonical forms; solutions of state equations; controllability, observability, and minimality; Lyapunov stability; pole placement; asymptotic observer and compensator design andquadratic regulator theory; extensions to multivariable systems; matrix fraction description approach; and elements of time-varying

systems. Prerequisites: EE 602, EE 603.

EE 651 Spread Spectrum and CDMA
Basic concepts, models, and techniques; direct sequence frequency hopping, time hopping, chirp and hybrid systems, jamming game, anti-jam systems, and analysis of coherent and non-coherent systems; synchronization and demodulation; multiple access systems; ranging and tracking; and pseudo-noise generators. Cross-listed with NIS 651.

EE 653 Cross-Layer Design for Wireless Networks
Introduction to wireless networks and layered architecture, principles of cross-layer design, impact of cross-layer interactions for different architectures: cellular and ad hoc networks, model abstractions for layers in cross-layer design for different architectures (cellular and ad hoc networks), quality of service (QoS) provisioning at different layers of the protocol stack with emphasis on physical layer, medium access control (MAC) and network layers, and examples of cross-layer design in the literature: joint optimizations involving beamforming, interference cancellation techniques, MAC protocols, admission control, power control, routing, and adaptive modulation. Cross-listed with NIS 653.

EE 663 Digital Signal Processing I
Review of mathematics of signals and systems including sampling theorem, Fourier transform, z-transform, and Hilbert transform; algorithms for fast computation: DFT, DCT computation, and convolution; filter design techniques: FIR and IIR filter design, time and frequency domain methods, window method, and other approximation theory based methods; structures for realization of discrete time systems: direct form, parallel form, lattice structure, and other state-space canonical forms (e.g., orthogonal filters and related structures); and roundoff and quantization effects in digital filters: analysis of sensitivity to coefficient quantization, limit cycle in IIR filters, scaling to prevent overflow, and role of special structures.

EE 664 Digital Signal Processing II
Implementation of digital filters in high speed architectures; multirate signal processing: linear periodically time varying systems, decimators and expanders, filter banks, interfacing digital systems operating at multiple rates, elements of subband coding, and wavelet transforms; signal recovery from partial data: from zero crossing, level crossing, phase only, and magnitude only data; and elements of spectral estimation: MA, AR and ARMA models. Lattice, Burg methods, and MEM. Prerequisite: EE 663.

EE 666 Multidimensional Signal Processing
Mathematics of multidimensional (MD) signals and systems; frequency and state space description of MD systems; multidimensional FFT; MD recursive and nonrecursive filters, velocity and isotropic filters, and their stability and design; MD spectral estimation with

applications in array processing; MD signal recovery from partial information, such as magnitude, phase, level crossing, etc.; MD subband coding for image compression; and selected topics from computer-aided tomography and synthetic aperture radar. Prerequisite: EE 603 or permission of instructor.

EE 670 Information Theory and Coding
An introduction to information theory methods used in the analysis and design of communication systems. Typical topics include: entropy, relative entropy, and mutual information; the asymptotic equipartition property; entropy rates of stochastic process; data compression; Kolmogorov complexity; channel capacity; differential entropy; the Gaussian channel; maximum entropy and mutual information; rate distortion theory; network information theory; and algebraic codes. Prerequisite: EE 605.

EE 672 Game Theory for Wireless Networks
Part I: Introduction to game theory: games in strategic form and Nash equilibrium, existence and properties of Nash equilibrium, Pareto efficiency, extensive form games, repeated games, Bayesian games and Bayesian equilibrium, types of games and equilibrium properties, and learning in games. Part II: Applications for wireless networks: resource allocation, enforcing cooperation in ad hoc networks, and cognitive radios. Cross-listed with NIS 672.

EE 674 Satellite Communications
Overview of communication theory, modulation techniques, conventional multiple access schemes, and SS/TDMA; satellite and frequency allocation, analysis of satellite link, and identification of the parameters necessary for the link calculation; modulation and coding; digital modulation methods and their comparison; error correction coding for the satellite channel, including Viterbi decoding and system performance; synchronization methods and carrier recovery; and effects of impairment on the channel. Prerequisite: EE 603.

EE 681 Fourier Optics
An introduction to two-dimensional linear systems, scalar diffraction theory, and Fresnel and Fraunhofer diffraction. Applications of diffraction theory to thin lenses, optical imaging systems, spatial filtering, optical information processing, and holography. Prerequisite: EE 603 or equivalent.

EE 700 Seminar in Electrical Engineering (ECE Seminar)
An ECE seminar on topics of current interest. Attendance by full-time Ph.D. students in the ECE Department is required. Attendance will be recorded. (0 credits/no cost)

EE 740 Selected Topics in Communication Theory*
A participating seminar in the area of modern

communications. Typical topics include high-resolution spectral estimation, nonparametric and robust signal processing, CFAR radars, diversity techniques for fading multipath channels, and adaptive nonlinear equalizers of optical communications.

EE 775 Selected Topics in Information Theory and Coding*
Current topics in information theory and coding. Typical topics include: basic theorems of information theory, entropy, channel capacity, and error bounds. Rate distortion theory: discrete source with a fidelity criterion, minimum distortion quantization, bounds on rate-distortion functions, error control codes: review of prerequisite linear algebra and field theory, linear block codes, cyclic algebraic codes, convolutional codes, and sequential decoding.

EE 787 Applied Antenna Theory
Brief review of electromagnetic theory; Maxwell's equations; the wave equations; plane waves and spherical waves; explanation of phenomenon of radiation; the incremental dipole antenna; and dipole antennas, including half-wave dipole and grounded monopole. Linear-antenna arrays, such as Yagi-Uda array and log-periodic array. Radiation from an aperture, such as rectangular and circular apertures. Prime-focus fed paraboloidal reflector antennas and far-field patterns, directivity, effects of scanning, and effects of random surface imperfections. Shaped-reflector paraboloidal reflector antennas and Cassegrain and Gregorian paraboloidal antennas. Offset paraboloidal reflectors and spherical reflectors. Tracking antennas, types of monopulse patterns, antenna noise, and concept of G/T.

EE 800 Special Problems in Electrical Engineering*
An investigation of a current research topic at the pre-master's level, under the direction of a faculty member. A written report is required, which should have the substance of a publishable article. Students with no practical experience who do not write a master's thesis are invited to take advantage of this experience. One to six credits for the degree of Master of Engineering (Electrical Engineering).

EE 801 Special Problems in Electrical Engineering*
An investigation of a current research topic beyond that of EE 800 level, under the direction of a faculty member. A written report, which should have the substance of a publishable article, is required. It should have importance in modern electrical engineering. This course is open to students who intend to be doctoral candidates and wish to explore an area that is different from the doctoral research topic. One to six credits for the degree of Doctor of Philosophy.

EE 900 Thesis in Electrical Engineering*
A thesis of significance to be filed in libraries, demonstrating competence in a research area of

electrical engineering. Five to ten credits with departmental approval for the degree of Master of Engineering (Electrical Engineering).

EE 950 Electrical Engineer Design Project*
An investigation of a current engineering topic or design. A written report is required. Eight to fifteen credits for the degree of Electrical Engineer.

EE 960 Research in Electrical Engineering*
Original research of a significant character, undertaken under the guidance of a member of the departmental faculty, which may serve as the basis for the dissertation required for the degree of Doctor of Philosophy. A report describing progress towards completing the thesis research for each semester in which the student is enrolled for research credit must be provided to the student's thesis committee. Credits to be arranged.

*By request.

back to top

Computer Engineering

CPE 514 Computer Architecture
Measures of cost, performance, and speedup; instruction set design; processor design; hard wired and microprogrammed control; memory hierarchies; pipelining; input/output systems; and additional topics as time permits. The emphasis in this course is on quantitative analysis of design alternatives. Prerequisite: CPE 550 or equivalent. Cross-listed with CS 514. (If student is required to complete CS/CPE 550 as a ramp course, CS/CPE 550 is a prerequisite).

CPE 521 Autonomous Mobile Robotic Systems
This course will offer the students an overview of the technology of autonomous mobile robotic systems—the mechanisms that allow a mobile robot to move through a real-world environment to perform its tasks. Since the design of any successful mobile robot involves the integration of many different disciplines -- among them kinematics, signal analysis, information theory, artificial intelligence, and probability theory -- the course will discuss all facets of mobile robotic system, including hardware design, wheel design, kinematics analysis, sensors and perception, localization, mapping, motion planning, navigation, and robot control architectures. Multi-robot systems will also be introduced due to their broader applications, such as search and rescue tasks, and exploring tasks. Pre-requisite: A familiarity with matrix algebra, calculus, and probability theory is required.

CPE 536 Integrated Services - Multimedia
Types of multimedia information: voice, data video facsimile, graphics, and their characterization; modeling techniques to represent multimedia information; analysis and comparative performances of different

models; detection techniques for multimedia signals; specification of multimedia representation based on service requirements; and evaluation of different multimedia representations to satisfy user applications and for generating test scenarios for standardization. Cross-listed with NIS 536.

CPE 537 Interactive Computer Graphics I
This is an introductory-level course to computer graphics. No previous knowledge of the subject is assumed. The objective of the course is to provide a comprehensive introduction, focusing on the underlying theory and thus providing strong foundations for both designers and users of graphical systems. The course will study the conceptual framework for interactive computer graphics; and introduce the use of OpenGL as an application programming interface (API) and cover algorithmic and computer architecture issues. Cross-listed with CS 537. (If student is required to complete CS/CPE 590 as a ramp course, CS/CPE 590 is a prerequisite).

CPE 540 Fundamentals of Quantitative Software Engineering I
This course introduces the subject of software engineering, also known as software development process or software development best practice from a quantitative, analytic-, and metrics-based point of view. Topics include introductions to: software life-cycle process models from the heaviest weight, used on very large projects, to the lightest weight, such as, extreme programming; industry-standard software engineering tools; teamwork; project planning and management; and object-oriented analysis and design. The course is case-history and project oriented. Prerequisites: Admission to the M.S. in CS program and completion of any required ramp courses, OR admission to the M.S. in QSE program. Undergraduates may take this course if they have senior status, or have obtained the written permission of the instructor. Cross-listed with CS 540.

CPE 542 Fundamentals of Quantitative Software Engineering II
This course is a project-oriented continuation of CS 540. It is intended for computer science majors interested in learning the software development process, but not interested in the full M.S. program in QSE or the Graduate Certificate in QSE. Students who have taken the defunct CPE 642 Software Engineering II, CS 568, and/or CS 569 may not take this course for credit. Prerequisite: CS 540. Cross-listed with CS 542.

CPE 545 Communication Software and Middleware
Communications in computer networks are not only enabled by physical links and hardware, but are also enabled by software and middleware. This course provides an understanding of software techniques in communications. It explores development models that address a broad range of issues in the design of communication software, including hardware and

software partitioning, layering, and protocol stacks. Other topics are configuration techniques, buffer and timer management, task and table managements, and multi-board communications software design. Communication middleware and agent technologies as enabling technology in networking will also be covered. Prerequisite: Graduate or undergraduate standing.

CPE 550 Computer Organization and Programming
This course provides an intensive introduction to material on computer organization and assembly language programming required for entrance into the graduate program in Computer Science or Computer Engineering. The topics covered are: structure of stored program computers; linking and loading; assembly language programming, with an emphasis on translation of high-level language constructs; data representation and arithmetic algorithms; basics of logic design; processor design: data path, hardwired control, and microprogrammed control. Students will be given assembly language programming assignments on a regular basis. No graduate credit for students in Computer Science or Computer Engineering. Cross-listed with CS 550.

CPE 555 Real-Time and Embedded Systems
The course provides the opportunity to learn various fundamental issues, as well as practical developments in the area of real-time embedded systems inherent in many hardware platforms and applications being developed for engineering and science, as well as ubiquitous systems, such as robotics and control systems. It will cover real-time operating systems, resource management, embedded software programming, real-time scheduling and synchronization, hardware/software co-design principles, real-time communication, and distributed embedded systems. As part of this course, students will learn to construct sample applications on representative platforms, such as autonomous robotics, smart sensors, and microprocessor systems.

CPE 558 Computer Vision
An introduction to the field of computer vision, focusing on the underlying algorithmic, geometric, and optic issues. The course starts with a brief overview of basic image processing topics (convolution, smoothing, and edge detection). It then proceeds onto various image analysis topics: binary images, moments-based shape analysis, Hough transform, image formation, depth and shape recovery, photometry, motion classification, and special topics. Prerequisite: CPE 590 or equivalent background. Corequisite: MA 112 or MA 115 or equivalent background. Cross-listed with CS 558.

CPE 560 Introduction to Networked Information Systems
An overview of the technical and application topics encountered in contemporary networked information systems, including the overall architecture of such

systems, data network architectures, secure transmission of information, data representations including visual representations, information coding/compression for storage and transmission, management of complex heterogeneous networks, and integration of next-generation systems with legacy systems. Cross-listed with NIS 560.

CPE 563 Networked Applications Engineering
Introduction to the engineering principles and practices to build networked applications, such as e-mail and www; programming networked applications using Web Services; coordinating the execution of application components on different computers on the network; ensuring consistency of data among the components in online banking-like applications; monitoring, recovery, and rejuvenation capabilities to handle component failures; authentication among components for eCommerce-like applications; application quality of service; middleware platforms that address these issues in practice; and large-scale networked application examples. Prerequisites: Graduate or senior undergraduate standing. Previous knowledge of programming is required. Cross-listed with NIS 563.

CPE 565 Management of Local Area Networks
Principles and practices of managing local area networks are presented from the perspective of a network systems engineer, including hands-on projects working with a real local area network (Cisco routers, switches, firewalls, etc.). The SNMP protocols and network management using SNMP are presented in terms of the general organization of information regarding network components and from the perspective of creating basic network management functions using SNMP. Techniques for troubleshooting practical networks, along with setting up and maintaining an IP network, are covered. The course includes a project-based learning experience. Cross-listed with NIS 565.

CPE 580 The Logic of Program Design
Introduction to the rigorous design of functional and procedural programs in a modern language (C++). The main theme is that programs can be reliably designed, proven, and refined if one pays careful attention to their underlying logic, and the emphasis of this course is on the logical evolution of programs from specifications. Programs are developed in the UNIX environment. No graduate credit for students in Computer Science or Computer Engineering. The necessary background in logic, program syntax, and UNIX is developed as needed, though at a fast pace: students are strongly advised to have completed course work equivalent to MA 502 and CS 570 prior to registering in CS 580. Corequisite: MA 502. Cross-listed with CS 580.

CPE 585 Medical Instrumentation and Imaging
This course presents both the basic physics together with the practical technology associated with such methods as X-ray computed tomography (CT), magnetic

resonance imaging (MRI), functional MRI (fMRI) and spectroscopy, ultrasonics (echocardiography and Doppler flow), and nuclear medicine (Gallium, PET, and SPECT scans), as well as optical methods such as bioluminescence, optical tomography, fluorescent confocal microscopy, two-photon microscopy, and atomic force microscopy. The course includes a laboratory component. Cross-listed with BME 504.

CPE 590 Introduction to Data Structures and Algorithms
Introduction to the design and analysis of algorithms. Standard problems and data structures are studied, as well as learning how to analyze the worst case asymptotic running time of an algorithm. Students will be given programming assignments on a regular basis. No graduate credit for students in Computer Science. Prerequisite: CPE 580. Cross-listed with CS 590.

CPE 591 Introduction to Multimedia Networking
The objective of this course is to introduce current techniques in multimedia communications especially as applied to wireless networks. The course will introduce the basic issues in multimedia communications, and networking. Topics covered include: multimedia information representation - text, images, audio, and video; introduction to information theory - information of a source, average information of a discrete memoryless source, and source coding for memoryless sources; multimedia compression - text, image, audio, and video; standards for multimedia communications; transmissions and protocols; circuit switched networks; the Internet; broadband ATM networks; packet video in the network environment; transport protocols - TCP/IP; TCP; UDP; RTP and RTCP; wireless networks - models, and characteristics; and error resilience for wireless networks. Cross-listed with NIS 591.

CPE 592 Multimedia Network Security
The objective of this course is to introduce current techniques in securing IP and multimedia networks. Topics under IP security will include classic cryptography, Diffie-Hellman, RSA, end-to-end authentication, Kerberos, viruses, worms, and intrusion detection. Topics from multimedia will include steganography, digital watermarking, covert channels, hacking, jamming, security features in MPEG-4, secure media streaming, wireless multimedia, copy control, and other mechanisms for secure storage and transfer of audio, image, and video data. Cross-listed with NIS 592.

CPE 593 Applied Data Structures and Algorithms
Data structures for representation of data and information to minimize data storage or computation time and for record-based information storage and retrieval. Formal algorithms for problem solving, including scalability of algorithms, classical sorting algorithms, computational algorithms (as in matrix manipulations), fault/failure analysis, etc. The course will include programming projects related to a

representative engineering problem(s).

CPE 600 Analysis of Algorithms
The complexity and correctness of algorithms: big oh, big omega, and big theta notations, recurrence relations, and their solutions. Worst, average, and amortized analysis of algorithms with examples. Basic and advanced data structures for searching, sorting, compression, and graph algorithms. Students will be given programming assignments on a regular basis. Prerequisites: CS 580, CS 590, and MA 502 or equivalent background. Cross-listed with CS 600.

CPE 608 Applied Modeling and Optimization
This course will deal with the main aspects of applied modeling and optimization suitable for engineering, science, and business students. Sample applications to be used as case studies include channel capacity computation (information theory), statistical detection and estimation (signal processing), sequential decision making/revenue maximization (business), and others. Topics will include introduction to convex and non-linear optimization and modeling, linear, quadratic and geometric program models and applications, stochastic modeling, combinatorial issues, gradient techniques, machine learning algorithms, stochastic approximation, genetic algorithms, and ant colony optimization. Pre-requisite: Some level of mathematical maturity (e.g., calculus and linear algebra) at the graduate level will be expected. Some computer programming background.

CPE 619 E-Commerce Technologies
The course provides an understanding of electronic commerce and related architectures, protocols and technologies. It describes the e-commerce concept, objectives and market drivers, as well as its requirements and underpinning techniques and technologies, including the Internet, WWW, multimedia, intelligent agents, client-server relations and data mining. Security in e-commerce is addressed, including types of security attacks, security mechanisms, Virtual Private Networks (VPNs), firewalls, intranets, and extranets. Implementation issues in e-commerce, including the design and management of its infrastructure and applications (ERP, CRM, SCM), are discussed. M-commerce is addressed; electronic payment systems with their associated protocols are described, and various B2C and B2B applications are presented. Also, policy and regulatory issues in e-commerce are discussed. Cross-listed with TM 619 and NIS 619. Prerequisite: CS 666 or CPE 678 or TM 610 or Mgt 776

CPE 621 Analysis and Design of Real-Time Systems
An introduction to the design methodologies and considerations for embedded and organic real-time systems. Review of available hardware technologies, throughput analysis, and hardware/software tradeoffs.

Analysis of language issues arising in real-time systems. Design of real-time kernels, context switching, memory allocation, and scheduling. Real-time data structures. Analysis of time/memory loading, latency issues, and data freshness. Exception detection and handling. A programming project or case study is required. Prerequisites: EE 605, CPE 514.

CPE 625 Systems Operational Effectiveness and Life-Cycle Analysis
This course discusses fundamentals of systems engineering. Initial focus is on need identification and problems definition. Thereafter, synthesis, analysis, and evaluation activities during conceptual and preliminary system design phases are discussed and articulated through examples and case studies. Emphasis is placed on enhancing the effectiveness and efficiency of deployed systems while concurrently reducing their operation and support costs. Accordingly, course participants are introduced to methods that influence system design and architecture from a long-term operation and support perspective. Cross-listed with SYS 625.

CPE 638 Interactive Computer Graphics II
Mathematical foundations and algorithms for advanced computer graphics. Topics include 3-D modeling, texture mapping, curves and surfaces, physics-based modeling, and visualization. Special attention will be paid to surfaces and shapes. The class will consist of lectures and discussion on research papers assigned for reading. In class, we will study the theoretical foundations and algorithmic issues. In programming assignments, we will use Open GL as the particular API for writing graphics programs. C/C++ programming skills are essential for this course. Prerequisites: CS 437, CS 537, or equivalent. Cross-listed with CS 638.

CPE 643 Logical Design of Digital Systems I
Design concepts for combinational and sequential (synchronous and asynchronous) logic systems; the design processes are described algorithmically and are applied to complex function design at the gate and register level. The designs are also implemented using software development tools, logic compilers for programmable logic devices, and gate arrays.

CPE 644 Logical Design of Digital Systems II
The design of complex digital logic systems using processor architectures. The architectures are implemented for reduced instruction set computers (RISC) and extended to complex instruction set computers (CISC). The emphasis in the course is the design of high-speed digital systems and includes processors, sequencer/controllers, memory systems, and input/output. Prerequisites: CPE 514, CPE 643.

CPE 645 Image Processing and Computer Vision
Multidimensional digital signals and systems, frequency analysis, sampling, and filtering; 2-D data transforms

with DTFT, DFT, DCT, and KLT; human visual system and image perception; image enhancement with histogram analysis, and linear and morphological operators; image restoration and image reconstruction from projections; image analysis, and feature detection and recognition; image coding with DCT and wavelet technologies, JPEG, and JPEG2000; and video coding with motion estimation, H.263, and MPEG, etc. Cross-listed with NIS 645.

CPE 646 Pattern Recognition and Classification
Introduction and general pattern recognition concerns and statistical pattern recognition: introduction to statistical pattern recognition, supervised learning (training) using parametric and nonparametric approaches, parametric estimation and supervised learning, maximum likelihood (ML) estimation, the Bayesian parameter estimation approach, supervised learning using nonparametric approaches, Parzen windows, nonparametric estimation, unsupervised learning and clustering, and formulation of unsupervised learning problems; syntactic pattern recognition: quantifying structure in pattern description and recognition, grammar-based approach and applications, elements of formal grammars, syntactic recognition via parsing and other grammars, graphical approaches, and learning via grammatical inference; neural pattern recognition: the artificial neural network model, introduction to neural pattern associators and matrix approaches, multilayer, feed-forward network structure, and content addressable memory approaches. The Hopfield approach to pattern recognition, unsupervised learning, and self-organizing networks. Prerequisite: EE 605.

CPE 654 Design and Analysis of Network Systems
Analysis of current networks, including classic telephone, ISDN, IP, and ATM. Attributes and characteristics of high-speed networks. Principles of network design, including user-network interface, traffic modeling, buffer architectures, buffer management techniques, call processing, routing algorithms, switching fabric, distributed resource management, computational intelligence, distributed network management, measures of network performance, quality of service, self-healing algorithms, and hardware and software issues in future network design. Cross-listed with NIS 654.

CPE 655 Queuing Systems with Computer Applications I
Queuing models will be developed and applied to current problems in telecommunication networks and performance analysis of networked computer systems. Topics include elementary queuing theory, birth-death processes, open and closed networks of queues, priority queues, conservation laws, models for time-shared computer systems, and computer communication networks. Prerequisite: EE 605, CS 505, or NIS 605.

Cross-listed with NIS 655 and CS 655.

CPE 656 Queuing Systems with Computer Applications II
This course is a continuation of CPE 655. Prerequisite: CPE 655, CS 655, or NIS 655. Cross-listed with NIS 656.

CPE 658 Image Analysis and Wavelets
The course emphasizes two main themes. The first is the study of wavelets as a newly emerging tool in signal analysis. The second is its applications in image processing and computer vision. In the first category, the following topics will be covered: time-frequency localization, windowed Fourier transform, continuous and discrete wavelet transforms, orthogonal and biorthogonal families of wavelets, and multiresolution analysis and its relation to subband coding schemes and use of wavelets in analysis of singularities. In the second category, applications of wavelets in problems of compact coding of images, edge and boundary detection, zero-crossing based representation, motion estimation, and other problems relevant to image processing and transmission will be considered. Prerequisite: EE 603.

CPE 668 Foundations of Cryptography
This course provides a broad introduction to cornerstones of security (authenticity, confidentiality, message integrity, and non-repudiation) and the mechanisms to achieve them. Topics include: block and stream ciphers, secret-key and public-key systems, key management, public-key infrastructure (PKI), digital envelope, integrity and message authentication, digital signature and non-repudiation, trusted third party, and certificates. Various security standards and protocols such as DES, PGP, and Kerberos will be studied. The course includes a project and some lab experiments related to running, analyzing, and comparing various security algorithms. Prerequisites: MA 502, CS 590, or permission of the instructor. Cross-listed with CS 668.

CPE 671 High-Speed Signal and Image Processing with VLSI
The design of ASCA (Application Specific Computer Architectures) for signal and image processing; topics include an overview of VLSI architectural design principles, signal and image processing algorithms, mapping algorithms onto array structures, parallel architectures and implementation, and systolic design for neural network processing. Prerequisites: EE 603, CPE 644.

CPE 678 Information Networks I
The first of a two-course sequence on modern computer networks. Focus is on the physical and data link levels of the OSI layers. Trace the evolution of client/server computing to the Internet. Topics covered include OSI layering, TCP/IP overview, the application of Shannon's and Nyquist's bandwidth theorems, Discrete Wave

Division Multiplexing, wireless transmission, local loops, QAM, TDM, SONET/SDH, circuit switching, ATM switching, knockout switch, ISDN, STM, framing, error detection and correction, CRC, ARQ protocol, sliding window protocols, finite state machines, Universal Modeling Language, PPP, ALOHA, CSMA, LANs, fast and gigabit Ethernet, bridges, and FDDI. A significant amount of time is spent on designing 802.3 LANs. Prerequisite: Graduate: CS 505; Undergraduate: MA 222. Cross-listed with NIS 678 and CS 666.

CPE 679 Information Networks II
Learn the technologies that make the Internet work. You will understand the TCP and IP protocols and their interaction. You will study the TCP slow start in low noise and high noise environments, the use of proxy servers, web caching, and gain understanding of the technologies used to make routers perform well under load. These include shortest path routing, new routing protocols, TCP congestion control, leaky bucket and token bucket admission control, weighted fair queueing, and random early detection of congestion. Networks are described in terms of their architecture, transport, routing, and management. Quality of Service (QoS) models are integrated with communication models. The course requires problem-solving and extensive reading on network technology. After an introduction to bridges, gigabit ethernet, routing, and the Internet Protocol, a fundamental understanding of shortest path and distance vector routing is taught. A “problem/solution” approach is used to develop how and why the technology evolved to keep engineering tradeoffs in focus. Continuation of Information Networks I with a focus on the network and transport layers of the OSI layers. Protocol definitions for distributed networks and performance analysis of various routing protocols, including Bellman-Ford, BGP, and OSPF. TCP over IP is discussed. Other topics include pipelining, broadcast routing, congestion control and reservations, Leaky and Token Bucket algorithms, weighted fair queuing, tunneling, firewalls, Ipv4, and IPv6. Network layers in SAN, including the different service categories, are discussed. The TCP and UDP transport protocols are discussed in-depth along with network security, DNS, SAN, SLIP, firewalls, and naming. Prerequisite: CS 666. Cross-listed with CS 667 and NIS 679.

CPE 680 Ad Hoc Networks
Ad hoc networking relates to a collection of network components that can self-organize and manage communications in a manner largely transparent to the user. Such networks have grown in importance as wireless network technologies have advanced, leading to dynamically changing network topologies. Representative topics, presented from the perspective of ad hoc networks, include routing protocols, performance metrics, implementations, applications such as sensor and peer-to-peer networks and security are presented.

CPE 682 Fuzzy Logic Systems
The geometry of fuzzy sets; the universe as a fuzzy set; fuzzy relational algebra; fuzzy systems; the fuzzy entropy theorem; the subsethood theorem; the fuzzy approximation theorem (FAT); fuzzy associative memories (FAM); adaptive FAMs (AFAM); fuzzy learning methods; approximate reasoning (linguistic modeling); different integration of neural networks and fuzzy systems; neuro-fuzzy controller and their applications; expert systems: knowledge acquisition, knowledge representation, and inference engines; hybrid expert systems (soft computing): knowledge-based systems, fuzzy systems, and neural networks; and applications: image processing, data compression, pattern recognition, computer vision, qualitative modeling, retrieval from fuzzy database, process control, robotics, and some industrial applications. Prerequisite: EE 605.

CPE 690 Introduction to VLSI Systems Design
This course introduces students to the principles and design techniques of very large scale integrated circuits (VLSI). Topics include: MOS transistor characteristics, DC analysis, resistance, capacitance models, transient analysis, propagation delay, power dissipation, CMOS logic design, transistor sizing, layout methodologies, clocking schemes, and case studies. Students will use VLSI CAD tools for layout and simulation. Selected class projects may be sent for fabrication. Cross-listed with PEP 690 and MT 690.

CPE 700 Seminar in Computer Engineering (ECE Seminar)
An ECE seminar on topics of current interest. Attendance by full-time Ph.D. students in the ECE Department is required. Attendance will be recorded. (0 credits/no cost)

CPE 732 Selected Topics VLSI Design and Simulation*
Current topics in VLSI, VHSIC, and ASIC design, simulation, and verification. Electronic design automation (EDA) tools. Design physics and processing and basic CMOS and bipolar circuit structures. Top-down design methods; formal specifications of circuits; simulation as an aid to circuit design and verification; and principles of functional and logical simulation before layout. Bottom-up circuit construction; hierarchical layout circuits; floor plan organization and routing of subcircuit interconnections; extraction of circuit from layout; critical path analysis. Class project and design, simulation, and layout of medium size circuit.

CPE 765 Selected Topics in Computer Engineering
A participating seminar on topics of current interest and importance in computer engineering.

CPE 800 Special Problems in Computer Engineering (M.Eng.)*
An investigation of current research topic at the

pre-master's level, under the direction of a faculty member. A written report is required, which should have the substance of a publishable article. Students with no practical experience who do not write a master's thesis are invited to take advantage of this experience. One to six credits for the degree of Master of Engineering (Computer Engineering).

CPE 801 Special Problems in Computer Engineering (Ph.D.)*
An investigation of a current research topic beyond that of CPE 800 level, under the direction of a faculty member. A written report is required, which should have importance in modern computer engineering and have the substance of a publishable article. This course is open to students who intend to be doctoral candidates and wish to explore an area that is different from the doctoral research topic. One to six credits for the degree of Doctor of Philosophy.

CPE 900 Thesis in Computer Engineering (M.Eng.)*
A thesis of significance to be filed in libraries, demonstrating competence in a research area of computer engineering. Five to ten credits with departmental approval for the degree of Master of Engineering (Computer Engineering).

CPE 950 Computer Engineer Design Project*
An investigation of current a engineering topic or design. A written report is required. Eight to fifteen credits for the degree of Computer Engineer.

CPE 960 Research in Computer Engineering (Ph.D.)*
Original research of a significant character undertaken under the guidance of a member of the departmental faculty that may serve as the basis for the dissertation required for the degree of Doctor of Philosophy. A report describing progress towards completing the thesis research for each semester in which the student is enrolled for research credit must be provided to the student's thesis committee. Credits to be arranged.

*By request.

back to top

Networked Information Systems

NIS 505 Probability for Telecommunications Managers
This course provides a background in probability and stochastic processes necessary for the analysis of telecommunications systems. Topics include axioms of probability, combinatorial methods, discrete and continuous random variables, expectation, Poisson processes, birth-death processes, and Markov processes. (Counts as credit only for the NIS program). Cross-listed with TM 605.

NIS 514 Computer Architecture
Measures of cost, performance, and speedup; instruction set design; processor design; hard-wired and microprogrammed control; memory hierarchies; pipelining; input/output systems; and additional topics as time permits. The emphasis in this course is on quantitative analysis of design alternatives. Prerequisite: CPE 550 or equivalent. Corequisite: MA 502. Prerequisites are satisfied by students admitted without the requirement that these courses be taken. Cross-listed with CPE 514 and CS 514.

NIS 536 Integrated Services - Multimedia
Types of multimedia information: voice, data video facsimile, graphics, and their characterization; modeling techniques to represent multimedia information; analysis and comparative performances of different models; detection techniques for multimedia signals; specification of multimedia representation based on service requirements; and evaluation of different multimedia representations to satisfy user applications and for generating test scenarios for standardization. Cross-listed with CPE 536 and CS 636.

NIS 560 Introduction to Networked Information Systems
An overview of the technical and application topics encountered in contemporary networked information systems, including the overall architecture of such systems, data network architectures, secure transmission of information, data representations including visual representations, information coding/compression for storage and transmission, management of complex heterogeneous networks, and integration of next-generation systems with legacy systems. Cross-listed with CPE 560.

NIS 563 Networked Applications Engineering
Introduction to the engineering principles and practices to build networked applications, such as e-mail and www; programming networked applications using Web Services; coordinating the execution of application components on different computers on the network; ensuring consistency of data among the components in online banking-like applications; monitoring, recovery, and rejuvenation capabilities to handle component failures; authentication among components for eCommerce-like applications; application quality of service; middleware platforms that address these issues in practice; and large-scale networked application examples. Prerequisites: Graduate or senior undergraduate standing. Previous knowledge of programming is required. Cross-listed with CPE 563.

NIS 565 Management of Local Area Networks
Principles and practices of managing local area networks are presented from the perspective of a network systems engineer, including hands-on projects working with a real local area network (Cisco routers, switches,

firewalls, etc.). The SNMP protocols and network management using SNMP are presented in terms of the general organization of information regarding network components and from the perspective of creating basic network management functions using SNMP. Techniques for troubleshooting practical networks, along with setting up and maintaining an IP network, are covered. The course includes a project-based learning experience. Cross-listed with CPE 565.

NIS 583 Wireless Communications
An overview of the main themes impacting wireless communication systems. Recent, present, and future generation wireless systems; cell-based systems; TDMA, FDMA, and CDMA approaches for wireless; mobile communications and system control; wireless LANs; wireless channels (multipath, fading, Doppler shifts, etc.); signal transmission in various physical environments (urban, rural, and building); 3G digital wireless systems; principles of receiver and transmitter architectures; interference and noise effects; digital signal processing in wireless systems; and contrasts between wireless and wireline communications for major applications. Cross-listed with EE 583.

NIS 584 Wireless Systems Security
Wireless systems and their unique vulnerabilities to attack; system security issues in the context of wireless systems, including satellite, terrestrial microwave, military tactical communications, public safety, cellular, and wireless LAN networks; and security topics: confidentiality/privacy, integrity, availability, and control of fraudulent usage of networks. Issues addressed include jamming, interception, and means to avoid them. Case studies and student projects are an important component of the course. Cross-listed with EE 584 and TM 684.

NIS 586 Wireless Networking: Architectures, Protocols, and Standards
This course addresses the fundamentals of wireless networking, including architectures, protocols, and standards. It describes concepts, technology, and applications of wireless networking as used in current and next-generation wireless networks. It explains the engineering aspects of network functions and designs. Issues such as mobility management, wireless enterprise networks, GSM, network signaling, WAP, mobile IP, and 3G systems are covered. Cross-listed with EE 586 and TM 586.

NIS 591 Introduction to Multimedia Networking
The objective of this course is to introduce current techniques in multimedia communications, especially as applied to wireless networks. The course will introduce the basic issues in multimedia communications and networking. Topics to be covered include: multimedia information representation - text, images, audio, and video; introduction to information theory - information of a source, average information of a discrete

memoryless source,and source coding for memoryless sources; multimedia compression - text, image, audio, and video; standards for multimedia communications; transmissions and protocols; circuit switched networks; the Internet; broadband ATM networks; packet video in the network environment; transport protocols - TCP/IP, TCP, UDP, RTP, and RTCP; wireless networks - models and characteristics; and error resilience for wireless networks. Cross-listed with CPE 591.

NIS 592 Multimedia Network Security
The objective of this course is to introduce current techniques in securing IP and multimedia networks. Topics under IP security will include classic cryptography, Diffie-Hellman, RSA, end-to-end authentication, Kerberos, viruses, worms, and intrusion detection. Topics from multimedia will include steganography, digital watermarking, covert channels, hacking, jamming, security features in MPEG-4, secure media streaming, wireless multimedia, copy control, and other mechanisms for secure storage, and transfer of audio, image and video data. Cross-listed with CPE 592.

NIS 593 Applied Data Structures and Algorithms
Data structures for representation of data and information to minimize data storage or computation time and for record-based information storage and retrieval. Formal algorithms for problem solving, including scalability of algorithms, classical sorting algorithms, computational algorithms (e.g., as in matrix manipulations), fault/failure analysis, etc. The course will include programming projects related to a representative engineering problem(s). Cross-listed with CPE 593.

NIS 605 Probability and Stochastic Processes I
Axioms of probability. Discrete and continuous random vectors. Functions of random variables. Expectations, moments, characteristic functions, and moment generating functions. Inequalities, convergence concepts, and limit theorems. Central limit theorem. Characterization of simple stochastic processes and wide-sense stationarity and ergodicity. Cross-listed with EE 605.

NIS 610 Error Control Coding for Networks
Error-control mechanisms; elements of algebra; linear block codes; linear cyclic codes; fundamentals of convolutional codes; Viterbi decoding codes in mobile communications; Trellis-coded modulation; concatenated coding systems and turbo codes; BCH codes; Reed-Solomon codes; implementation architectures and applications of RS codes; and ARQ and interleaving techniques. Cross-listed with EE 610.

NIS 611 Digital Communications Engineering
Waveform characterization and modeling of speech/image sources; quantization of signals; uniform, nonuniform, and adaptive quantizing; pulse code modulation (PCM) systems; differential PCM (DPCM);

linear prediction theory and adaptive prediction; delta modulation and sigma-delta modulation systems; subband coding with emphasis on speech coding; and data compression methods like Huffman coding, Ziv-Lempel coding, and run length coding. Cross-listed with EE 611.

NIS 612 Principles of Multimedia Compression
Brief introduction to nformation theory; entropy and rate; Kraft-McMillan inequality; entropy codes - Huffman and arithmetic codes; scalar quantization - quantizer design issues, the Lloyd quantizer, and the Lloyd-Max quantizer; vector quantization - LBG algorithm, and other quantizer design algorithms; structured VQs; entropy constrained quantization; bit allocation techniques: generalized BFOS algorithm; brief overview of linear Algebra; transform coding: KLT, DCT, and LOT; subband coding; wavelets; wavelet based compression algorithms (third generation image compression schemes)- EZW algorithm, the SPIHT algorithm, and the EBCOT algorithm; video compression: motion estimation and compensation; image and video coding standards: JPEG/ JPEG 2000, MPEG, H.263, and H.263+; source coding and error resilience. Cross-listed with EE 612.

NIS 619 E-Commerce Technologies
This course provides an understanding of electronic commerce and related architectures, protocols, and technologies. It describes the e-commerce concept, objectives, and market drivers, as well as its requirements and underpinning techniques and technologies, including the Internet, WWW, multimedia, intelligent agents, client-server relations, and data mining. Security in e-commerce is addressed, including types of security attacks, security mechanisms, Virtual Private Networks (VPNs), firewalls, intranets, and extranets. Implementation issues in e-commerce, including the design and management of its infrastructure and applications (ERP, CRM, and SCM), are discussed. M-commerce is addressed, electronic payment systems with their associated protocols are described, and various B2C and B2B applications are presented. Also, policy and regulatory issues in e-commerce are discussed. Cross-listed with TM 619, CPE 619, and CS 619. Prerequisite: CS 666, CPE 678, TM 610, or Mgt 776.

NIS 626 Optical Communication Systems
Components for and design of optical communication systems; propagation of optical signals in single mode and multimode optical fibers; optical sources and photodetectors; optical modulators and multiplexers; optical communication systems: coherent modulators, optical fiber amplifiers and repeaters and transcontinental and transoceanic optical telecommunication system design; and optical fiber LANs. Cross-listed with EE 626, PEP 626 and MT 626.

NIS 630 Enterprise Systems Management
This course focuses on the role of information

technology (IT) in reengineering and enhancing key business processes. The implications for organizational structures and processes, as the result of increased opportunities to deploy information and streamlining business systems, are covered.

NIS 631 Management of Information Technology Organizations
The objective of this course is to investigate and understand the organizational infrastructure and governance considerations for information technology. It concentrates on developing students' competency in current/emerging issues in creating and coordinating the key activities necessary to manage the day-to-day IT functions of a company. Topics include: ITs key business processes, IT governance, organizational structure, value of IT, role of the CIO, outsourcing, systems integration, managing emerging technologies and change, and human resource considerations. This course should be taken before NIS 632. Cross-listed with MGT 781.

NIS 632 Strategic Management of Information Technology
The objective of this course is to address the important question, "How to improve the alignment of business and information technology strategies?" The course is designed for advanced graduate students. It provides the student with the most current approaches to deriving business and information technology strategies, while ensuring harmony among the organizations. Topics include business strategy, business infrastructure, IT strategy, IT infrastructure, strategic alignment, methods/metrics for building strategies, and achieving alignment. This course should be taken after NIS 631. Cross-listed with MGT 780.

NIS 633 Integrating IS Technologies
This course focuses on the issues surrounding the design of an overall information technology architecture. The traditional approach in organizations is to segment the problem into four areas - network, hardware, data, and applications. This course will focus on the interdependencies among these architectures. In addition, this course will utilize management research on organizational integration and coordination science. The student will learn how to design in the large, make appropriate choices about architecture in relationship to overall organization goals, understand the different mechanisms available for coordination, and create a process for establishing and maintaining an enterprise architecture. Prerequisites: MGT 772, MGT 773 and MGT 776 or their equivalents. Cross-listed with MGT 784.

NIS 645 Image Processing and Computer Vision
Multidimensional digital signals and systems, frequency analysis, sampling, and filtering; 2-D data transforms with DTFT, DFT, DCT, and KLT; human visual system and image perception; image enhancement with histogram analysis and linear and morphological

operators; image restoration and image reconstruction from projections; image analysis and feature detection and recognition; image coding with DCT and wavelet technologies and JPEG and JPEG2000; and video coding with motion estimation, H.263, and MPEG, etc. Cross-listed with CPE 645.

NIS 651 Spread Spectrum and CDMA
Basic concepts, models, and techniques; direct sequence frequency hopping, time hopping, chirp and hybrid systems, jamming game, anti-jam systems, and analysis of coherent and non-coherent systems; synchronization and demodulation; multiple access systems; ranging and tracking; and pseudo-noise generators. Cross-listed with EE 651.

NIS 653 Cross-Layer Design for Wireless Networks
Introduction to wireless networks and layered architecture, principles of cross-layer design, impact of cross-layer interactions for different architectures: cellular and ad hoc networks, model abstractions for layers in cross-layer design for different architectures (cellular and ad hoc networks), quality of service (QoS) provisioning at different layers of the protocol stack with emphasis on physical layer, medium access control (MAC) and network layers, and examples of cross-layer design in the literature: joint optimizations involving beamforming, interference cancellation techniques, MAC protocols, admission control, power control, routing, and adaptive modulation. Cross-listed with EE 653.

NIS 654 Design and Analysis of Network Systems
Analysis of current networks, including classic telephone, ISDN, IP, and ATM. Attributes and characteristics of high-speed networks. Principles of network design, including user-network interface, traffic modeling, buffer architectures, buffer management techniques, call processing, routing algorithms, switching fabric, distributed resource management, computational intelligence, distributed network management, measures of network performance, quality of service, self-healing algorithms, and hardware and software issues in future network design. Cross-listed with CPE 654.

NIS 655 Queuing Systems with Communications Applications I
Queuing models will be developed and applied to current problems in telecommunication networks and performance analysis of networked computer systems. Topics include elementary queuing theory, birth-death processes, open and closed networks of queues, priority queues, conservation laws, models for time-shared computer systems, and computer communication networks. Prerequisite: NIS 605, EE 605, or CS 505. Cross-listed with CPE 655 and CS 655.

NIS 656 Queuing Systems with Computer Applications II

This course is a continuation of NIS 655. Prerequisite: NIS 655. Cross-listed with CPE 656 and CS 656.

NIS 672 Game Theory for Wireless Networks
Part I: Introduction to game theory: games in strategic form and Nash equilibrium, existence and properties of Nash equilibrium, Pareto efficiency, extensive form games, repeated games, Bayesian games and Bayesian equilibrium, types of games and equilibrium properties, and learning in games. Part II: Applications for wireless networks: resource allocation, enforcing cooperation in ad hoc networks, and cognitive radios. Cross-listed with EE 672.

NIS 678 Information Networks I
Introduction to information networks, architecture, and communication models. Protocol definition for distributed network,s including X.25 and SNA and performance analysis of various layers of protocols. Local area networks (LANs): CSMA/CD, token bus and token ring technologies, and performance analysis of LANs. Routing and flow control techniques. Prerequisite: Understanding of probability concepts. Cross-listed with CPE 678 and CS 666.

NIS 679 Information Networks II
Advanced network architectures, including integrated digital networks and Integrated Services Digital Networks (ISDN), narrowband and broadband ISDN. Architectural design based on topological considerations, bandwidth assignment and connection management for services, flow control, and routing designs. Satellite communications, multimedia services and communication techniques, ATM, SONET, and SDH. Prerequisite: NIS 678. Cross-listed with CPE 679 and CS 667.

NIS 691 Information Systems Security
History of network security; classical information security; cryptosecurity; kerberos for IP networks; private and public keys; nature of network security; fundamental framework for network security; analysis and performance impact of network topology; vulnerabilities and security attack models in ATM, IP, and mobile wireless networks; security services, policies, and models; trustworthy systems; intrusion detection techniques - centralized and distributed; emulation of attack models and performance assessment through behavior modeling and asynchronous distributed simulation; principles of secure network design in the future; and projects in network security and student seminar presentations.

NIS 700 Seminar in Networked Information Systems (ECE Seminar)
An ECE seminar on topics of current interest. Attendance by full-time Ph.D. students in the ECE Department is required. Attendance will be recorded. (0 credits/no cost)

NIS 765 Selected Topics in Networked Information Systems
An ECE seminar on topics of current interest. Attendance by full-time Ph.D. students in the ECE Department is required. Attendance will be recorded. (0 credits/no cost)

NIS 800 Special Problems in Networked Information Systems*
An investigation of a current research topic at the pre-master's level, under the direction of a faculty member. A written report, which should have the substance of a publishable article, is required. Students with no practical experience who do not write a master's thesis are invited to take advantage of this experience. One to six credits for the degree of Master of Engineering (Networked Information Systems).

NIS 900 Thesis in Networked Information Systems (M.Eng.)*
A thesis of significance to be filed in libraries, demonstrating competence in a research area of electrical engineering. Five to ten credits with departmental approval for the degree of Master of Engineering (Networked Information Systems).

*By request.

back to top