Electrical and Computer Engineering

Faculty and Fields of Interest

Brown, David A Professor of Electrical and Computer Engineering (1995), BS 1985 University of Rhode Island, MS 1988, PhD 1991 Naval Postgraduate School. *Specializations:* Acoustic transduction, fiber optic sensors and systems, underwater acoustics, acoustic properties of materials.

Buck, John R Associate Professor of Electrical Engineering and Marine Science and Technology (1996), SB 1989, SM 1991, PhD 1996 Massachusetts Institute of Technology. *Specializations:* Underwater acoustics, signal processing, marine mammal bioacoustics.

Chen, Chi Hau Chancellor Professor of Electrical and Computer Engineering (1968), BS 1959 National Taiwan University, Taiwan, MS 1962 University of Tennessee, PhD 1965 Purdue University. *Specializations:* Pattern recognition, neural networks, image processing and machine vision, communications theory, ultrasonic non-destructive testing.

Cory, Lester W Chancellor Professor of Electrical and Computer Engineering (1963), BS 1963 Bradford Durfee College of Technology (UMass Dartmouth), MS 1970 Northeastern University, MEd 1974 Bridgewater State College, DS (Hon) University of Rhode Island. *Specializations:* Rehabilitation engineering, computer systems, HF/VHF communications.

Costa, Antonio H (Interim Dean, College of Engineering) Professor of Electrical and Computer Engineering (1985), BS 1983, MSEE 1985 Southeastern Massachusetts University (UMass Dartmouth), PhD 1994 University of Rhode Island. *Specializations:* Mixed time-frequency representations, spectral estimation, signal processing, image processing.

Thomas J Curry Director, Advanced Technology and Manufacturing Center (2003) and Professor of Electrical and Computer Engineering (1983), BS 1964 Southeastern Massachusetts University (UMass Dartmouth), MS 1966 Worcester Polytechnic Institute, PhD 1975 University of Rhode Island *Specializations:* Signal processing, computer systems, underwater systems.

Fain, Gilbert Chancellor Professor of Electrical and Computer Engineering and Marine Science and Technology (1968), BSEE 1958, MSEE 1961, PhD 1967 University of Rhode Island. *Specializations:* Ocean systems, instrumentation and measurement systems, underwater acoustics, active circuits.

Fortier, Paul J Professor of Electrical and Computer Engineering (1994), BS 1978 University of Lowell (UMass Lowell), MS 1981 Southeastern Massachusetts University (UMass Dartmouth), DSc 1993 University of Massachusetts Lowell. *Specializations:* Database systems, real-time systems, operating systems, computer architecture, networks, computer performance evaluation.

Helgeland, Robert C Professor of Electrical and Computer Engineering (1970), BSEE 1968 Southeastern Massachusetts University (UMass Dartmouth), MSEE 1970 Northeastern University, Registered Professional Engineer. *Specialization:* Marine electronic systems.

Kasilingam, Dayalan P (Chairperson, Department of Electrical and Computer Engineering) Professor of Electrical Engineering and Marine Science and Technology (1993), BA 1981 Cambridge University MS 1982, PhD 1987 California Institute of Technology. *Specializations:* Remote sensing, applied electromagnetics, adaptive signal processing and wireless communications.

Lemay, Gerald Professor of Electrical and Computer Engineering (1978), BS 1971 University of Massachusetts Amherst, MS 1978 Southeastern Massachusetts University (UMass Dartmouth), PhD 1988 University of Rhode Island. *Specialization:* Renewable energy.

Liu, Hong Professor of Electrical and Computer Engineering (1990), BS 1982, MS 1984 Hefei Polytechnic University, China, PhD 1989 Polytechnic University, New York. *Specializations:* Computer networks, compilers, programming languages.

Michel, Howard Assistant Professor of Electrical and Computer Engineering (1999), BS 1975 New Jersey Institute of Technology, MS 1981 University of Southern California, MS 1988 University of Massachusetts Amherst, PhD 1999 Wright State University. *Specializations:* Distributed artificial intelligence, artificial neural networks, distributed computing, computer vision, computer networks.

Mitza, Theophano Assistant Professor of Electrical and Computer Engineering (2003), BS 1985 Aristotelean University of Thessalonika, MS 1988, PhD 1991 University of Rochester. *Specializations:* Knowledge-based systems, intelligent agents, distributed systems, Internet computing.

Nardone, Steven C Professor of Electrical and Computer Engineering (1984), BSEE 1972, MSEE 1974, PhD 1982 University of Rhode Island. *Specializations:* Systems theory, modern control and estimation theory, signal processing, fuzzy systems.

Notaros, Branislav Associate Professor of Electrical and Computer Engineering (1999), BS 1988, MS 1992, PhD 1995 University of Belgrade. *Specializations:* Computational and applied electromagnetics, antennas, scattering, microwaves, biomedical applications of electromagnetic waves, characterization of mobile telephone antennas and human head interaction.

Payton, Karen L Professor of Electrical and Computer Engineering (1989), BS 1977 Carnegie-Mellon University, MSEE 1981, PhD 1986 Johns Hopkins University. *Specializations:* Digital signal processing, speech processing, speech acoustics, auditory perception.

Rancour, David (Graduate Program Director) Associate Professor of Electrical and Computer Engineering (1988), BSEE 1978 University of Vermont, MSEE 1982 Northeastern University, PhD 1988 Purdue University. *Specializations:* Semiconductor defects, solid state devices and materials.

Schmidlin, Dean J Professor of Electrical and Computer Engineering (1982), BSE 1964 Manhattan College, MS 1966, PhD 1972 New York University. *Specializations:* Digital signal processing, linear discrete-time systems (both time-varying and time-invariant).

Viall, Philip Professor of Electrical and Computer Engineering (1983), BSEE 1981, MSEE 1983 Southeastern Massachusetts University (UMass Dartmouth). *Specializations:* Computer networking, assembly languages, rehabilitation engineering.

Xing, Liudong Assistant Professor of Electrical and Computer Engineering (2002), BE 1996 Zhengzhou University, China, MS 1998 Chinese Academy of Sciences, PhD 2002 University of Virginia. *Specializations:* Hardware and software reliability, network reliability, fault-tolerant computing, risk assessment.

Contact

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Graduate Electrical and Computer Engineering at UMass Dartmouth

Department of Electrical and Computer Engineering
College of Engineering

The Department of Electrical and Computer Engineering at the University of Massachusetts Dartmouth offers graduate programs leading to a Master of Science Degree in either Electrical Engineering or Computer Engineering and a Doctor of Philosophy Degree in Electrical Engineering with options in either Electrical Engineering or Computer Engineering.

Key technical/research areas within Electrical Engineering are signals and systems; applied acoustics; applied electromagnetics; and electronics and solid-state devices. Key technical/research areas within Computer Engineering are database systems, networks, distributed computing, artificial intelligence, Internet computing, and fault tolerance. An emphasis in the marine applications of these broad technical areas is supported by specialized courses and MS thesis or PhD dissertation research. The marine emphasis in electrical and computer engineering graduate studies at the Dartmouth campus is unique within the UMass system. Additional information on program specializations is contained in subsequent sections.

For students wishing advanced training without a degree, the department offers five formal 15 credit graduate certificate programs, in Electrical Engineering Systems, Communications, Digital Signal Processing, Acoustics, and Computer Systems Engineering.

All of our programs offer small classes, close contact with a diverse faculty, and easy access to well-supported research facilities to provide state-of-the-art learning and research experiences. Courses are scheduled to permit either full-time or part-time study, and are offered at times that are convenient for students employed in industry and government.

Resources

The Department of Electrical and Computer Engineering maintains and operates a wide variety of facilities for applications in engineering education and research. Some special facilities include the Acoustic Sensors Laboratory, Marine Electronics Laboratory, Microcomputer Laboratory, Microwave Laboratory, Remote Sensing Laboratory, Machine Vision Laboratory, and Ultrasonic Signal Processing Laboratory. In addition to undergraduate laboratories, the department maintains numerous Windows- and UNIX-based servers and workstations.

The Center for Rehabilitation Engineering, housed in the College of Engineering; the Center for Marine Science and Technology (SMAST); and the Advanced Technology and Manufacturing Center (ATMC)—described elsewhere in this catalogue—offer opportunities for applied research for engineering graduate students. As part of its commitment to marine science and technology the university maintains a fifty-five foot research vessel. The region, along with neighboring Rhode Island, is host to U.S. government laboratories, major industries, and several educational facilities, many of which are involved in marine science and technology.

Admission Requirements

Students possessing a bachelor's or master's degree and a strong academic background in electrical engineering, computer engineering, or similar disciplines are encouraged to apply for admission to the master's or doctoral programs.

Applicants for the MS or PhD degrees must submit the required application materials to the Graduate Office. In addition,

- Transcripts should show class rank if available.
- The three letters of recommendation should be from persons in the field of the applicant's academic major at the institution most recently attended or be from supervisors familiar with the applicant's recent job performance. For PhD applicants, the recommendations must also address the student's ability to conduct independent scholarly research.
- The essay should be from 300 to 600 words in length. This essay should indicate your graduate study objectives, research interests and experience, undergraduate and graduate experience, and business or industry experience if applicable. If you are also applying for a teaching or research assistantship, include any special skills or experience that would assist us in our decision on the assistantship award.
- Graduate Record Examination scores for the General Test must be submitted by degree-seeking applicants, except by those who are or are about to be graduates of the University of Massachusetts Dartmouth or who are or are about to be recipients of an ECE graduate certificate.
- Foreign students' scores on the Test of English as a Foreign Language (TOEFL) should be 550 minimum for admission and 600 minimum to be eligible for a teaching assistantship (213/250 for TOEFL computer-based scores).

Admission to the MS and PhD programs is competitive. In general, students must exceed the minimum requirements stated below to gain admission. However, all students who meet the minimum requirements will be considered. In special cases, students who do not meet these minimum requirements, but who otherwise show evidence of strong academic, professional, or research ability, may be accepted upon approval of the ECE Graduate Committee.

- The applicant must possess a minimum of a bachelor's degree in electrical engineering, computer engineering, or related field of engineering, science or mathematics, from a college or university of recognized standing. Applicants with backgrounds different than those for the option to which they are applying may be admitted with additional course requirements needed to meet program prerequisites.
- Applicants to the MS program must have demonstrated scholastic competence. Typically, MS applicants with an undergraduate cumulative grade point average of 3.0 on a 4.0 grading scale for all engineering, math and physics courses will be considered. Applicants to the PhD program must have demonstrated superior scholastic achievement.
- PhD applicants must demonstrate a potential for conducting independent scholarly research. Recommendations are very important in the evaluation of research potential and should, therefore, specifically address the subject of research potential. Master's theses or undergraduate projects are also considered in the evaluation of research potential.

Students apply for entrance to a certificate program through the Graduate Office; see "Certificate Programs" section below.

Course Availability and Offerings

Graduate courses are usually offered before 10 am or after 3:30 pm once or twice a week, to accommodate both full-time and part-time students.

Additional information on courses and their scheduling may be found on the web at www.umassd.edu/engineering/electrical/grad.html and in the "Handbook for Electrical and Computer Engineering Graduate Students," available in the ECE Office, II-213; in the College of Engineering Office, Dion 326; or on-line at www.umassd.edu/engineering/ece/ece.graduate.handbook.cfm

Degree Requirements (MS degree)

Transfer of Credit

A maximum of six credits may be transferred from another institution. A maximum of nine UMass Dartmouth credits earned prior to admission to an ECE graduate or certificate program, but all credits earned in an ECE certificate program, can be applied to a degree program.

Enrollment Without Degree Intentions

The department offers a choice of certificate programs, which provide specific career benefits to working professionals. The courses in these programs are compatible with degree requirements, if students later decide to transition to a degree program. Certificate programs are described in detail in a subsequent section of this chapter. Students accepted to one of our formal certificate programs may subsequently apply that coursework to a degree without restriction in the number of credits.

Individuals may enroll in graduate courses as non-degree students without applying for admission to a graduate or certificate program, when space is available and with permission of the instructor. Non-degree special students should have at least a 2.75 out of a 4.00 grade point average with a Bachelor of Science in electrical engineering, computer engineering, other engineering disciplines, science, or mathematics. Before registering for a course, special students are required to discuss their preparation with the instructor to determine that they have sufficient background to be successful. Registration may be done at the first class meeting. If the non-degree student is later admitted to a graduate or certificate program, a maximum of nine credits of these courses may be transferred by written application to the Graduate Program Director.

Graduate Assistantships and Financial Aid

Financial assistance is available to full-time graduate students on a competitive basis. Most full-time students have teaching assistantships or research assistantships within the ECE department, while others may be supported by fellowships or employed in other University departments. Requests for financial assistance should be made on the admission application.

Other inquiries regarding graduate student financial assistance should be made to the Director of the ECE Graduate Program. For information about loans or other assistance, please consult the chapter on "Expenses and Financial Assistance."

The Master of Science degree program at the University of Massachusetts Dartmouth provides sufficient structure to ensure that each graduate of the program has a firm foundation to go on to further graduate studies or to succeed at the advanced level in industry. However, there is enough program flexibility to allow students to pursue studies of their own particular interest.

Each candidate for the Master of Science Degree must obtain a minimum of 30 graduate credits with the following constraints: 1) maintain a grade point average of at least 3.0 out of a 4.0 grading scale in all courses, 2) obtain no more than two course grades below B-minus and 3) courses with grades of C- or below will not count toward graduation requirements.

The MS in Computer Engineering and the MS in Electrical Engineering, although separate degrees, share some common requirements:

Master of Science Degree, All Course Work Tracks

1
A minimum of 30 credits must be completed. These must be in accordance with a plan of study filed by the student and approved by the graduate advisor.
2
At least 24 of the required 30 credits must be at the graduate level (500 series or higher). As many as six credits of 400 series courses will be allowed to compensate for variations in the student's background; a grade of B or better is required. Undergraduate courses in excess of the 6-credit limit are allowed, but will not count for credit toward the degree.
3
Pass a MS comprehensive examination at the completion of 30 credtis of course work. Students with ECE graduate committee approval, apply for a waiver of the comprehensive examination.

Master of Science Degree, Project Track

1
A minimum of 30 credits must be completed. These must be in accordance with a plan of study filed by the student and approved by the graduate advisor.
2
At least 24 of the required 30 credits must be graduate level (500 series or higher). As many as six credits of 400 series courses will be allowed to compensate for variations in the student's background. In these courses a grade of B or better is required. Undergraduate courses in excess of the six-credit limit are allowed, but will not count for credit toward the degree.
3
At least three credits of graduate project (ECE 600) must be competed for the project track. A written report and an oral presentation of the project work are required to satisfy this program track.

Master of Science Degree, Thesis Track

1
A minimum of 30 credits must be completed. These must be in accordance with a plan of study filed by the student and approved by the graduate advisor.
2
At least 24 of the required 30 credits must be graduate level (500 series or higher). As many as six credits of 400 series courses will be allowed to compensate for variations in the student's background. In these courses a grade of B or better is required. Undergraduate courses in excess of the six-credit limit are allowed, but will not count for credit toward the degree.
3
At least six credits of graduate thesis (ECE 600) must be completed for the thesis track. In addition to the written thesis, oral presentation of the thesis work is required prior to completion of the program.

BS/MS Undergraduate/Graduate Integrated Program Option

The department offers an integrated program that allows qualified UMass Dartmouth undergraduate majors in both Computer Engineering and Electrical Engineering to proceed directly to the master's degree program and complete both degrees with a reduction in overall credits required. See the current *General Catalogue* for information on this option.

Graduate Certificates in Electrical and Computer Engineering

Course Requirements, Master of Science, All Tracks

Master of Science in Electrical Engineering

Required of all students:

•
ECE 521 Random Signal Analysis I
•
A graduate math course that can be satisfied with Mathematics of Systems Analysis (ECE 581) or a math course approved by the student's advisor.
•
ECE 561 Computer Systems
•
Either ECE 540 Electromagnetics or ECE 557 Fundamentals of Acoustics
•
A depth requirement: Submission of a coherent program of study that includes at least two more graduate courses, beyond the requirements above, in one of the technical areas listed below. The student's advisor and the ECE Graduate Program Director must approve the program of study.

Signals and Systems Specializations:
Advanced Automation
Communications Theory
Digital Signal Processing
Systems and Control
Underwater Systems

Applied Acoustics Specializations:
Acoustic Transduction
Marine Acoustics
Marine Mammal Acoustics
SONAR and its Applications
Speech Processing
Underwater Propagation

Applied Elecromagnetics Specializations:
Antennas
Wireless Communications
Remote Sensing
Smart Antennas
Radar

Electronics and Solid-State Devices Specializations:
Marine Electronics
Solid-State Devices

Master of Science in Computer Engineering

Required of all students:

•
ECE 560 Computer Systems Performance Analysis
•
ECE 562 Computer Architecture
•
ECE 565 Operating Systems
•
A graduate math course that can be satisfied with Mathematics of Systems Analysis (ECE 581) or a math course approved by the student's advisor.
•
A depth requirement: Submission of a coherent program of study that includes at least two more graduate courses, beyond the requirements above in one of the technical areas listed below. The student's advisor and the ECE Graduate Program Director must approve the program of study, selected from one of the following *Computer Engineering Specialization Areas:*
Computer Systems Specification, Analysis, Design, and Performance Assessment
Database Systems
Distributed and Parallel Systems
Microprocessors
Networking
Fault-Tolerant computing
Artificial Intelligence, Neural Networks, and Computer Vision
•
A breadth requirement: Students must also take one graduate course from a specialization area different from that selected to satisfy the depth requirement.

Students are required to satisfy prerequisite requirements for all graduate courses taken. In particular, ECE 561 Computer Systems is a prerequisite for ECE 562. For students pursuing the MS in Computer Engineering, ECE 561 will count toward the six-credit limit on 400-level courses.

Additional details can be found in the "Handbook for Electrical and Computer Engineering Graduate Students."

A certificate offers the working professional recognition of a coherent program of advanced study at the graduate level. The certificate programs are compatible with the MS degree requirements, enabling certificate recipients to transition to a degree program without loss of credits. Each certificate requires 15 credits of graduate course work. A student may complete multiple certificates, provided an application has been approved for each and the student satisfies the requirements of each. Each certificate meets a subset of the degree requirements for the MS in either the Electrical Engineering or Computer Engineering option. Currently, the Electrical and Computer Engineering Department offers five certificate programs, as listed below.

Acceptance to a Certificate Program

Applicants apply for acceptance to a graduate certificate program through the Office of Graduate Studies. Applicants follow the general procedures for graduate degree acceptance into the MS in Electrical Engineering, but in an abbreviated form. Thus, they submit a shortened application form and supply an essay and official transcripts of all post-secondary work, as instructed herein. However, they are not required to submit GRE scores or recommendation letters.

Other Policies

Prospective students can take up to two courses (with permission of the instructor) for the certificate before completing their official acceptance to the certificate program. It is possible for acceptance to be offered with a contingency that the student must also take one or more undergraduate prerequisite courses. Certificate students may use no more than one 400-level course toward their certificate program. A 400-level course may be used only when the related graduate course specified in the certificate program is not offered during the student's enrollment in the certificate program.

Other graduate policies, such as those for longevity of credit, acceptable grades, and repeatability of courses, apply to certificate students as to degree students.

Acoustics Certificate

Complete these required courses:
ECE 521 Random Signals and Systems I
ECE 557 Fundamentals of Acoustics
ECE 574 Discrete-Time Signal Processing
ECE 597 Underwater Acoustics I

Choose one of the following four courses:
ECE 575 Sonar Signal Processing
ECE 598 Underwater Acoustics II
ECE 679 Geophysical, Radar and Speech Signal Processing
ECE 699 Acoustic Transduction and Electroacoustic Transducers

Total: 15 credits

Communications Certificate

Complete these required courses:
ECE 521 Random Signals and Systems I
ECE 571 Digital Communications

Choose one of the following three courses:
ECE 569 Advanced Computer Networks
ECE 576 Computer Communications
ECE 591 Wireless Communications

Choose one of the following two courses:
ECE 531 Radio Frequency Propagation in Wireless Systems
ECE 672 Signal Detection Theory

Choose one of the following two courses:
ECE 595 Independent Study: Specialized Communications Systems
ECE 671 Information Theory

Total: 15 credits

Computer Systems Engineering Certificate

Complete these required courses:
ECE 560 Computer Systems Performance Analysis
ECE 562 Computer Architecture
ECE 565 Computer Operating Systems

Choose two courses, each of which represents a distinct computer engineering area.
ECE 541 Database Systems I
ECE 566 Microprocessors I
ECE 569 Advanced Computer Networks
ECE 592 Project Engineering
The following three courses represent one area; hence, one may be used:
ECE 609 Distributed Computing Architecture
ECE 610 Distributed Computing Programming
ECE 611 Current Topics in Distr. Computing

Total: 15 credits

Digital Signal Processing Certificate

Complete these required courses:
ECE 521 Random Signals and Systems I
ECE 574 Discrete-Time Signal Processing

Choose one of the following three courses:
ECE 571 Digital Communications
ECE 584 Estimation Theory
ECE 672 Signal Detection Theory

Choose one of the following three courses:
ECE 523 Digital Spectral Analysis
ECE 640 Wavelets
ECE 674 Time-Frequency Signal Processing

Choose one of the following three courses:
ECE 642 Advanced Topics in Signal Processing
ECE 675 Sonar Signal Processing
ECE 679 Geophysical, Radar and Speech Signal Processing

Total: 15 credits

Electrical Engineering Systems Certificate

Complete these required courses:
ECE 521 Random Signals and Systems I
ECE 581 Mathematics of Systems Analysis
ECE 561 Computer Systems

Choose two of the following courses:
ECE 557 Fundamentals of Acoustics
ECE 574 Discrete-Time Signal Processing
ECE 571 Digital Communications
ECE 592 Project Engineering
or any other course approved by the ECE Graduate Program Director

Total: 15 credits

Doctor of Philosophy in Electrical Engineering

The Doctor of Philosophy Degree in Electrical Engineering provides students with the education to be researchers and leaders in their fields of specialization. The program provides both breadth and depth through a flexible structure of formal course work, independent study, and research. The focus of the PhD program is an individualized program of study that prepares the student for PhD dissertation research. The dissertation is an original scholarly contribution to the research literature of the field and is the culmination of the student's academic career. The PhD program offers opportunities for graduate studies in the areas of signal processing; sensors; communications; antennas and electromagnetics; database systems; intelligent systems; networking; distributed computing; fault tolerant computing; microwave and solid state electronics; remote sensing; wireless communications; control and tracking; systems and estimation theory.

An emphasis in the marine applications of these broad areas is supported by specialized courses and dissertation research. The marine emphasis in electrical and computer engineering graduate studies at the Dartmouth campus is unique within the UMass system. The faculty, and their research interests, are listed earlier in this bulletin.

Doctor of Philosophy Degree Requirements

Students are required to successfully complete an approved program of study. Successful completion of the doctoral program of study is indicated by a grade point average of 3.0 or better on a 4.0 grading scale with no more than two grades below B-. Typically, a minimum of 24 credits beyond the MS requirement or 54 credits beyond the BS is expected (exclusive of dissertation research). Although it is not necessary to obtain the MS degree before proceeding in the PhD program, the MS core courses and specialization or thesis requirements must be fulfilled either through the program of study at the University of Massachusetts Dartmouth or through prior graduate studies at another institution.

PhD students must pass either the Electrical Engineering or the Computer Engineering PhD qualifying examination. The examination, which is based on both the broad background of the undergraduate electrical engineering or computer engineering program and the more in-depth and specialized introductory graduate level course work, verifies that the student is sufficiently prepared to continue advanced graduate studies in support of a general PhD

research area. Typically, students entering the program with the BS take the qualifying examination after completing at least 24 course credits. Students entering the program with an MS degree would normally take the examination in the first year of admission.

For the Electrical Engineering Option, the topics on the undergraduate section of the qualifying exam are (relevant courses are listed in parentheses): (a) Fields and Waves (ECE 335, 336), (b) Electronic Devices and Circuits (ECE 311, 312), (c) Signals and Linear Systems Theory (ECE 321, 322), and (d) Digital Logic and Computers (ECE 260, 263). The four topics on the graduate section of the qualifying exam for the Electrical Engineering Option are: (a) ECE 521 (Random Signals), (b) ECE 581 (Mathematics of Systems Analysis) or other appropriate math course (selected by the student at the time that seating for the examination is requested), and (c) Two of the following six courses—ECE 574 (Discrete-Time Signal Processing), ECE 557 (Fundamentals of Acoustics), ECE 540 (Electromagnetics), ECE 571 (Digital Communications), ECE 561 (Computer Systems). The student specifies the two courses from list (c) when sitting for the examination is requested.

For the Computer Engineering Option, the topics on the undergraduate section of the qualifying exam are (relevant courses are listed in parentheses): (a) Computer Systems Software (ECE 367), (b) Electronic Devices and Circuits (ECE 311), (c) Fundamentals of Computing (ECE 264, 350), and (d) Digital Logic and Computer Architecture (ECE 260, 263). The four topics on the graduate section of the qualifying exam for the Computer Engineering Option are: (a) ECE 560 (Computer Systems Performance Evaluation), (b) ECE 562 (Advanced Computer Architecture), (c) ECE 565 (Computer Operating Systems), and (d) ECE 581 (Mathematics of Systems Analysis), CIS 560 (Theoretical Computer Science) or other appropriate math course selected by the student when sitting for the examination is requested.

PhD candidates must also pass the PhD comprehensive examination. This examination verifies that the student is sufficiently prepared to conduct scholarly research in the selected area of the PhD dissertation. Consequently, the PhD comprehensive examination focuses on advanced graduate studies and a formal PhD research proposal.

The comprehensive examination is conducted in two parts: a written examination followed by an oral examination. The oral examination will be scheduled within four weeks of successful completion of the written examination. The form and content of both parts of the examination are set by the student's committee. The oral examination is nominally two hours. The comprehensive examination is scheduled by the student at the convenience of the committee members, administered by the major advisor, and is composed by the committee members. Successful completion of both the written and oral examination is determined by the unanimous consent of the committee. Students failing to give satisfactory performance on either part of the examination are allowed a single re-examination of either all or a portion of either examination as determined by the committee.

PhD candidates must successfully complete a PhD dissertation. Successful completion of the PhD dissertation is indicated by the satisfactory oral defense of a written dissertation that represents an original contribution to the scholarly research literature of the field. The dissertation normally involves 18 credits of PhD dissertation research (ECE 701).

ECE 411 three credits
Active Circuits I
3 hours lecture
Prerequisite: ECE 312
Design course in the manipulation and generation of signals using analog integrated circuits, especially operational amplifiers. Methods are developed to understand and control the impact of practical component limitations like input and output impedance, frequency response, offset voltages, bias currents and cost. Stability considerations and compensation techniques are studied, and students are introduced to noise considerations in circuit design. Students design, build, and test many of the circuits discussed in the course such as precision voltage and current sources, V/I and I/V converters, and active filters. Students work individually on small designs but in teams on larger ones.

ECE 413 three credits
Introduction to VLSI Design
3 hours lecture
Prerequisites: ECE 311
Introduction to design of Very Large Scale Integrated Circuits (VLSI), taught at the transistor level. Computer tools are used to create and simulate integrated circuit layouts. Levels of design automation covered include Full Custom layout, Schematic Driven layout, Standard Cells and fully automated synthesis of HDL code. Students are required to complete a project that can be submitted for fabrication.

ECE 414 three credits
Introduction to Analog Integrated Circuit Design
3 hours lecture
Prerequisite: ECE 413
Introduction to the design of CMOS analog integrated circuits (ICs), with occasional references to bipolar IC's to make comparisons. Students are required to complete the design of a reasonably complex IC and make a class presentation of its design methodology and simulation results.

ECE 424 three credits
Introduction to Solid State Electronics
Prerequisite: PHY 114 or permission of instructor
Solid state device behavior. Among the topics covered are semiconductor fundamentals, p-n junction theory, and both the bipolar and the field effect transistor. Emphasis is placed on those transistor parameters that need to be considered in VLSI and microwave applications.

ECE 431 three credits
Antennas and Propagation
3 hours lecture

Note: Equivalent courses taken elsewhere satisfy undergraduate course prerequisites.

Prerequisite: ECE 336
Solution of Maxwell's equations for radiation problems. Hertzian dipole as a fundamental radiation element is described. Radiation patterns, directivity, gain, antenna impedance, radiation efficiency, and antenna polarization are defined. The course reviews wire dipole antennas, loop antennas, antennas above ground plane, and corner reflector antennas. Topics include receiving antenna properties, antenna arrays, and microstrip patch and slot antennas. Rectangular horn antennas and parabolic reflector antennas are studied. Also discussed are ground-wave propagation and ionospheric propagation.

ECE 432 three credits
Wireless Communications
3 hours lecture
Prerequisite: Permission of instructor
Introduction to the principles and practice of wireless communications. The course presents the concepts of frequency reuse and cellular structure and covers propagation effects, multipath fading, digital and analog modulation, diversity and equalization, multiple access, and wireless networks. The course also presents modern wireless systems and standards. The focus of the course is to understand wireless communications at a systems level and is designed as a senior elective for ELE and CPE majors. Basic understanding of electromagnetic wave propagation and communication theory is expected. The course includes a project related to new technological advances in wireless systems.

ECE 433 three credits
Advanced Electromagnetic Theory
3 hours lecture
Prerequisite: ECE 336 or permission of instructor
Vector analysis in a generalized orthogonal coordinate system. The course reviews basic electromagnetic-field theorems. Two- and three-dimensional boundary value problems are addressed and solution methods presented. Topics include wave propagation in multi-layer media and wave polarization. Waveguides with cylindrical conducting boundaries, special waveguide types, waveguide devices, cavity resonators, radiation, and scattering are also studied.

ECE 435 three credits
Microwave and RF Engineering
3 hours lecture
Prerequisite: ECE 335
Review of transmission line theory. The concept of impedance transformation is presented. The characteristics of coaxial lines, waveguides, and microstrip lines are studied in detail. Propagation and impedance properties of these lines are derived. Smith charts are used for designing matching and tuning circuits. The use of S-parameters and the analysis of multi-port networks are presented. Passive multi-port devices such as microwave power couplers and dividers are described. The fundamentals of microwave and RF filters and resonators are discussed, and their implementation using microstrip lines and waveguides is also presented.

ECE 436 three credits
Wireless System Design
3 hours lecture
Prerequisite: ECE 335
Design of microwave and RF wireless systems. Transmission line theory and network analysis are reviewed and the fundamentals of antenna theory are presented. Basic antennas such as dipoles, slots, and horns are covered. System noise and its description are discussed. Operational concepts of microwave detectors and mixers are presented. The design and analysis of detector and mixer circuits are covered. Operational concepts of microwave and RF amplifiers, oscillators, and frequency synthesizers are presented. the integration of components in microwave and RF receivers and their performance are covered. Microwave systems such as radar, remote sensors, and radiometers are also described.

ECE 441 three credits
Electromechanical Energy Conversion
3 hours lecture
Prerequisite: ECE 311
Transformers and rotating machines. Among the AC devices studied are three-phase transformers, induction motors, reluctance motors, stepper motors, and synchronous motors. DC motors and electric vehicle drive circuits are included.

ECE 442 three credits
Power Electronics
3 hours lecture
Prerequisite: ECE 311
Electronic circuit design techniques using power semiconductor devices for industrial and residential applications. Typical applications include switching DC power supplies, power conditioners, DC-to-AC inverters, DC-to-DC converters, motor controllers, AC-to-AC converters, and utility-intertie.

ECE 443 three credits
Power Systems I
3 hours lecture
Prerequisite: ECE 335
First course of a two-semester sequence covering energy sources such as fossil-fuels, nuclear, hydro, photovoltaic, wind, and biomass; loads such as residential and commercial end-users; and the transmission-distribution networks that connect them.

ECE 444 three credits
Power Systems II
3 hours lecture
Prerequisite: ECE 443
Second course of a two-semester sequence continuing with the modeling, analysis, and design of power generating plants, loads, and transmission-distribution networks.

ECE 454 three credits
Fault-Tolerant Computing
3 hours lecture
Prerequisites: ECE 260; MTH 212, 331 or ECE 384; or permission of instructor
Techniques for designing and analyzing dependable and fault-tolerant computer-based systems. Topics addressed include: fault, error, and failure cause-and-effect relationships; fault avoidance techniques; fault tolerance techniques, including hardware redundancy, software redundancy, information redundancy, and time redundancy; fault coverage; time-to-failure models and distributions; reliability modeling and evaluation techniques, including fault trees, cut-sets, reliability block diagrams, binary decision diagrams, and Markov models. In addition, availability modeling, safety modeling, and trade-off analysis are presented.

ECE 455 three credits
Computing Methods of Numerical Analysis
3 hours lecture
Prerequisites: ECE 160 or CIS 115; MTH 212; and MTH 213 or MTH 211
Mathematical methods useful to the computer engineer, including topics from numerical analysis and linear algebra. Students learn how and when to apply a particular numerical analysis tool or method and can analyze and interpret the results provided by the method. Emphasis is placed on selecting appropriate numerical tools for a variety of basic problems, applying them, and studying their reliability, efficiency, and computer implementation. A large number of problems are solved using the computer.

ECE 456 three credits
Computer Architecture
3 hours lecture
Prerequisites: ECE 161 or CIS 215; and ECE 260; or permission of instructor
An examination of various components that make up a computer system, including CPU, memory, input/output, and buses, as well as how they all work together to form a function-

ing computer system. The major advances in the computer organization and architecture including von Neumann architecture, interrupts, the family concept, microprocessors, cache memory, virtual memory, virtual I/O, pipelining, RISC, superscalar processors, IA-64 (EPIC), micro-programmed control unit as well as parallel processing are also presented. This course includes team projects.

ECE 457 two credits
Design Project I
1 hour lecture, 3 hours laboratory
Prerequisite: Senior standing in electrical or computer engineering
The goal of this course is to prepare the student to undertake and successfully complete the capstone design experience embodied in the subsequent course ECE 458 Design Project II. The objectives of this course include providing a firm basis in the methodology of planning and executing an engineering design project, exposing the student to real case studies involving engineering design, forming a design project group and developing group skills in executing design projects, preparing a design project plan, and having the student groups select a design project of appropriate complexity and their faculty advisor in preparation for the subsequent course ECE 458. Included in this course are two major written reports and two major oral presentations as well as minor reports and presentations.

ECE 458 three credits
Design Project II
1 hour lecture; 6 hours laboratory
Prerequisites: ECE 457
Continuation of ECE 457. Goals of this course are for the student to conduct, successfully complete, and professionally present the results of his/her capstone design project under the oversight of his/her faculty advisor. The objectives of this course include executing the design project plan prepared in ECE 457, conducting group activities associated with the execution of the design project, participating in design reviews, preparing the project report, and presenting and demonstrating the results of the project activities to a group of faculty, students, and industry representatives. Included in this course are three major written reports and three major oral presentations as well as minor reports and presentations.

ECE 460 three credits
Computer Systems Performance Evaluation
3 hours lecture
Prerequisites: ECE 263, ECE 367, ECE 350, and MTH 331 (or ECE 384)
Probability and statistics with applications to principles of queuing theory, computer systems simulation, and empirical analysis techniques as applied to computer systems modeling. This course is oriented toward a practical application of theory and concepts to computer systems hardware and software performance.

ECE 461 three credits
Microprocessors I
3 hours lecture
Prerequisites: ECE 263 and ECE 367
Design and construction of a microprocessor based computer system. Students will learn how a computer operates at the chip level and develop an understanding of the interdependence of hardware and software. Students will develop circuitry and software to control CPU interaction with SRAM, ROM and peripheral chips, as well as reset and boot-up control and interrupt handling. At the end of the course, students will have produced a working computer.

ECE 462 three credits
Microprocessors II
3 hours lecture
Prerequisite: ECE 461
Design and construction of an advanced microprocessor computer system. This course is a continuation of ECE 461 in which students will modify the previous design to accommodate multiple processors to achieve parallel computation or use an advanced microprocessor to achieve higher performance.

ECE 463 three and one half credits
Software Engineering
3 hours lecture, 1.5 hours laboratory
Prerequisites: ECE 264 and ENL 266
The software development process: user requirements, specifications, design, coding, testing, maintenance, documentation and management. This course is designed to enable participants to acquire the ability to (1) apply software engineering principles and practices to the planning and development of an actual software product, (2) work as a member of a software project team, (3) produce professional software engineering documents, and (4) deliver oral presentations associated with software development.

ECE 465 three credits
Microprogrammed Design
3 hours lecture
Prerequisite: ECE 263
Microprocessor and microcontroller design and operations using state machine and microprogramming techniques. Students will learn how to describe, design and test architectures from assembly language perspectives and learn how to develop microprogrammed implementations of an assembly level instruction set for a variety of platforms.

ECE 466 three credits
Database Programming
2 hours lecture, 3 hours laboratory
Prerequisites: ECE 26;, MTH 181 or MTH 350;, and MTH 331 or ECE 384
Database management system specification, design, implementation, operations and evaluation introduced using a current industrial grade database management system (Oracle, IBM DB2, Microsoft SQL or Informix UDS). SQL language concepts including object-relational operations, object-language relational schema modeling using entity-relationship modeling concepts, data definition language, data manipulation language, data control language, persistent stored modules, triggers and assertions specification and use, applied within both ad-hoc and embedded systems environments are investigated in a studio classroom context. The laboratories include team database application development projects utilizing all major elements of contemporary object-relational database languages aimed at developing least cost solutions to contemporary information management problems.

ECE 467 three credits
Advanced Database Design
2 hours lecture, 3 hours laboratory
Prerequisite: ECE 466
Database management systems and operations. Students learn how to describe and design a database, how to describe and specify embedded and ad-hoc database applications, and how to develop least cost solutions to information management problems integrated through a series of database design exercises implemented within an industry grade database management system. Topics include database management systems architecture and operations, database applications specification, database stored procedure design, database embedded program design, and database ad-hoc specification and design.

ECE 468 three credits
Advanced Computer Architecture
3 hours lecture
Prerequisite: ECE 456
Advanced computer design, emphasizing fundamental limitations and tradeoffs in designing high performance computer systems. Students develop an understanding of the theoretical foundations in both hardware and software by studying parallel computer models; program partitioning, granularity, and latency; processor architectures and interconnects; and memory hierarchy, interleaving and bandwidth. Specific architectures such as shared memory

Note: Equivalent courses taken elsewhere satisfy undergraduate course prerequisites.

multi-processors, message passing multi-computers, and superscalar, supervector, VLIW, and dataflow designs will be explored.

ECE 469 three credits
Computer Networks
3 hours lecture
Prerequisites: ECE 201 and ECE 367
Introduction to current networking methodologies. Backbone design, layered architecture, protocols, local and wide area networks, internetworking, broadband, electrical interface, and data transmission. Simulation projects are included.

ECE 470 three credits
Network Application Programming
3 hours lecture, 2 hours laboratory
Prerequisite: ECE 469
Methodologies of network application programming, design and implementation. Client-Server model, threads, and synchronization in a distributed computing environment, communication protocols (TCP/UDP and TCP/IP), inter-process communication using sockets, remote procedure calls (RPC), and the transport interface (XTI) are covered. This course includes the design, implementation and testing of both network application projects and an intranet laboratory in which the students work in teams.

ECE 471 three credits
Communication Theory
3 hours lecture
Prerequisite: ECE 384
Probability theory, signals and linear networks, Fourier transforms, random processes and noise are reviewed. Analog communications including amplitude and frequency modulation with and without noise are studied. Digital communications including baseband pulse modulation, quantization, sampling theory, digital pulse shaping, matched filter, Nyquist criterion and error rates due to noise are covered.

ECE 472 three credits
Advanced Communications Systems
3 hours lecture
Prerequisite: ECE 471
Continuation of ECE 471. Signal-space analysis is introduced. Passband digital transmission, direct sequence and frequency-hop spread-spectrum modulation and multiuser radio are studied. Entropy is discussed and channel capacity is derived. Block and convolutional error-control coding is covered.

ECE 475 three credits
Digital Signal Processing
3 hours lecture
Prerequisite: ECE 322
Methods and techniques for digital signal processing, covering the basic principles governing the design and use of digital systems as signal processing devices. Review of discrete-time linear systems, Fourier transforms and z-transforms. Topics include allpass and minimum-phase systems, linear phase systems and group delay, sampling, decimation, interpolation, discrete-time filter design and implementation, discrete Fourier series, discrete Fourier transform, the fast Fourier transform, and basic spectral estimation. Applications to digital processing of real data are included.

ECE 477 three credits
Digital Processing of Speech Signals
3 hours lecture
Prerequisites: ECE 384 and ECE 475; or permission of instructor
Applications of digital signal processing to speech signals. Course goals are to reinforce concepts learned in prerequisite courses, to introduce new tools needed to deal with time-varying signals and to have students apply what they have learned to their own voices. A semester design project is a large component of this course. Topics include a review of digital signal processing and random signal fundamentals, brief introduction to articulatory and acoustic phonetics, time-domain methods for speech processing, short-time Fourier analysis, homomorphic speech processing, linear predictive coding of speech, and applications.

ECE 481 three credits
Control Theory I
3 hours lecture
Prerequisite: ECE 321
Classical control of single-input single-output systems. Both time domain and frequency domain analysis and design techniques are presented. Subjects included are signal flowgraphs, control devices, electrical motors, root-locus, Bodé plots, stability, Routh-Hurwitz criterion, Nyquist stability, phase lead/lag controllers and PID controllers.

ECE 482 three credits
Control Theory II
3 hours lecture
Prerequisite: ECE 481
Continuation of ECE 481. Control Theory II introduces control of discrete systems, modern control theory, and nonlinear control. Concepts of discrete systems, state variables, observability, controllability, phase plane and describing functions method are surveyed.

ECE 485 three credits
Advanced Engineering Mathematics
3 hours lecture
Prerequisites: MTH 213 (or MTH 211) and MTH 212
Selective topics in advanced engineering mathematics. The mathematical areas considered are linear algebra, partial differential equations, complex analysis, and calculus of variations. Representative examples of the topics covered are real and complex matrices, eigenvalues and eigenvectors, method of separating variables for solving partial differential equations, solution of partial differential equations by Fourier series and integrals, integration of complex functions, Taylor and Laurent series, conformal mapping, unconstrained and constrained optimization, and Lagrange multipliers.

ECE 486 three credits
Database Systems I
3 hours lecture
Prerequisite: ECE 367
Introduction to database systems from an architectural and functional perspective. The course provides an overview of database systems architecture, computer representation of information, computer data storage, properties of persistent data, database structuring models (relational, object, object-relational, and entity-relationship), transaction processing models, concurrency control techniques, database transaction recovery, and security. These concepts will then be explored by examining and comparing the architecture and operations of database systems such as conventional, real-time, temporal, fault-tolerant, distributed, heterogeneous, secure and others.

ECE 489 three credits
Network Security
3 hours lecture
Prerequisite: ECE 469 or permission of instructor
Principles and practices of security in computer networks. This course covers the theoretical foundations of securing computer networks including cryptography and models. It steps through the practical process of defending networking resources. It also reveals various case studies, large and small, to familiarize the techniques that attackers use. An Internet Testbed is facilitated for students to experiment attacks and defenses.

ECE 491 three credits
Introduction to Ocean Engineering
2 hours lecture, 3 hours laboratory
Lab includes boat trips and LMSET Acousto/Optic Tank Experiments
Prerequisite: Senior standing in College of Engineering
Study of a range of ocean engineering topics

to provide a basis for the design of systems, which must function in the ocean environment. Topics include ocean waves, water quality, ocean optics, vehicle dynamics, underwater structures, and ocean sensing systems. The course also includes laboratory experiments aboard the UMass Dartmouth research vessel Lucky Lady and experiments in the acousto/optic tank at the UMass Dartmouth Laboratory for Marine Science and Technology.

ECE 493 three credits
Principles of Underwater Systems
3 hours lecture
Prerequisite: ECE 491
Principles that govern the design and operation of underwater systems, for engineering students. The student develops a broad understanding of underwater systems that will prepare him/her for more advanced studies and/or engineering projects in underwater systems. Topics include generation of sonar signals and sound propagation in the ocean. The course also includes laboratory experiments aboard the UMass Dartmouth research vessel Lucky Lady and experiments in the acousto/optic tank at the UMass Dartmouth Laboratory for Marine Science and Technology.

Graduate Courses in Electrical and Computer Engineering

ECE 511 three credits
Application of Active Circuits
3 hours lecture
Prerequisite: Permission of instructor
Advanced analog design techniques with emphasis on using operational amplifiers. Topics include multi-pole transfer functions and stability, noise calculations, interfacing with digital circuits, and specialized analog applications. Problems are solved using numerical and circuit simulation software packages.

ECE 521 three credits
Random Signals and Systems I
3 hours lecture
Prerequisites: Probability and random variables; or permission of instructor
Random variables and probabilistic description of signals and systems. The course provides the analytical tools for studying random phenomena in engineering systems and provides graduate students with an extensive treatment of probability theory, Bayes theorem, random variables, distribution and density functions, conditional distributions, moments, functions of random variables, characteristic functions, stochastic processes, Gaussian processes, stationary processes, correlation functions, power spectral density, response of systems to random inputs, mean square error estimation, filtering and prediction, and noise analysis. The course prepares students for a wide range of courses in communications, signal processing, acoustics, control, and other areas of engineering in which random signals and systems have an important role.

ECE 523 three credits
Digital Spectral Analysis
3 hours lecture
Prerequisites: ECE 521, ECE 574; or permission of instructor
Spectral estimation techniques with particular emphasis on performance/resolution tradeoffs. The course enables participants to understand spectral estimation and acquire a working knowledge of the spectral analysis techniques available, with a critical understanding of the advantages and limitations of all spectral estimation techniques studied. The student learns: (1) the limitations of Fourier transform based spectral estimators; (2) the benefits and limitations of high resolution methods; (3) how to choose accurate and appropriate models; (4) the "state-of-the-art" in modern spectral estimation; (5) how the modern spectral estimators perform in practice; (6) when to select each spectral estimation method.

ECE 524 three credits
Solid State Electronics
3 hours lecture
Prerequisite: Permission of instructor
Solid state device behavior. Among the topics covered are semiconductor fundamentals, p-n junction theory, and both the bipolar and the field effect transistor. Emphasis is placed on those transistor parameters that need to be considered in VLSI and microwave applications.

ECE 525 three credits
Digital Filters
3 hours lecture
Prerequisites: ECE 521, ECE 574; or permission of instructor
Design, simulation, and implementation of digital filters. After a review of classical FIR and IIR design techniques and modern AR, MA, and ARMA techniques, the course immerses the student in problem solving with digitized signals and DSP microprocessors. These problems include noise reduction, echo cancellation, signal detection, etc. Computer simulation is an integral part of the course, and students are expected to have some familiarity with small computer operating systems and assembly language programming concepts.

ECE 527 three credits
Active Remote Sensing of the Environment
3 hours lecture
Prerequisites: ECE 336, ECE 384; or permission of instructor
Principles and applications of active remote sensing techniques. Course focuses on microwave and millimeter wave radar techniques. Topics include radar equation, detection theory, scattering from targets and natural surfaces, and imaging systems. The following sensors are covered: synthetic aperture radar (SAR), radar scatterometers, altimeters, polarimetric radars and interferometric radars. Applications include ocean wave and wind measurements, soil moisture measurements, biomass measurements, measurement of land topography, and precipitation studies. Course also includes laboratory computer exercises for analyzing and processing real sensor data.

ECE 528 three credits
Passive Remote Sensing of the Environment
3 hours lecture
Prerequisites: ECE 336, ECE 384; or permission of instructor
Principles and applications of passive remote sensing techniques. Course addresses the use of sensors such as thematic mappers, optical multispectral scanners, infrared radiometers and multispectral microwave radiometers. The following sensors are covered: Thematic Mapper, SPOT, AVHRR, SSM/I and WINDRAD. Applications include ocean color and productivity measurements, ocean temperature measurements, salinity measurements, ocean wind measurements, marine pollution monitoring, and atmospheric measurements. Course also includes laboratory computer exercises for analyzing and processing real sensor data.

ECE 532 three credits
Radar Engineering
3 hours lecture
Prerequisite: ECE 435, ECE 436, or permission of instructor
Fundamentals of microwave radar engineering and radar system analysis. The course covers the radar equation, radar detection theory, noise analysis, radar cross-section, continuous wave and pulsed systems, moving target indicators, pulse compression, radar transmitters and receivers. Also covered are radar systems such as pulsed Doppler radar, synthetic aperture radar (SAR), inverse synthetic aperture radar (ISAR), polarimetric radar and interferometric radar. Applications include target detection, radar remote sensing, satellite oceanography, and terrain mapping.

ECE 533 three credits

Note: Equivalent courses taken elsewhere satisfy undergraduate course prerequisites.

VLSI Design
3 hours lecture
Prerequisite: ECE 311; or permission of instructor
Design of Very Large Scale Integrated Circuits (VLSI), taught at the transistor level. Computer tools are used to create and simulate integrated circuit layouts. Levels of design automation covered include Full Custom layout, Schematic Driven layout, Standard Cells and fully automated synthesis of HDL code. Required readings from the current literature lead to a formal written report on recent developments in VLSI. Students are required to complete and present at least one project. Some designs may be fabricated.

ECE 535 three credits
Analog Integrated Circuit Design
3 hours lecture
Prerequisite: ECE 413 or ECE 533 or permission of instructor
Introduction to the design of CMOS analog integrated circuits (IC's), with occasional references to bipolar IC's to make comparisons. Required readings from the current literature lead to a formal written report on recent developments in analog IC's. Students are required to complete the design of a complex IC and make a class presentation of its design methodology and simulation results.

ECE 536 three credits
Applied Computational Electromagnetics
3 hours lecture
Prerequisite: ECE 336 or permission of instructor
Numerical techniques for practical applications in electromagnetic scattering, propagation, and radiation. The course reviews fundamentals of electromagnetic field and wave theory and covers all basic classes of computational techniques used in modern applied electromagnetics. Numerical techniques include the method of moments, finite difference method, finite element method, and physical optics. Applications cover static and quasi-static problems, transmission lines, scattering, and antennas.

ECE 537 three credits
Antenna Theory
3 hours lecture
Prerequisite: ECE 336 or permission of instructor
Antenna fundamentals, antenna arrays, and basic types of antennas for wireless communication. Mathematical solution of Maxwell's equations for radiation problems is introduced. Basic antenna parameters are defined and discussed. Electrically small antennas are analyzed. Theory of receiving antennas is presented. Topics in antenna arrays include the array factor, pattern multiplication, multidimensional arrays, and phased arrays. Several types of antennas are studied, including wire and microstrip antennas.

ECE 538 three credits
Advanced Antenna Engineering
3 hours lecture
Prerequisite: ECE 537 or permission of instructor
Advanced antenna engineering concepts, with in-depth studies of analysis and synthesis techniques, broadband and aperture antennas, and antenna measurements. The synthesis of arrays and design of broadband antennas are presented. Topics in aperture antennas include Huygens' equivalence principle, horn antennas, slot antennas, and large reflector antennas. The use of antennas as devices in wireless and radar systems is covered, along with antenna measurements. Integral equations for antenna current distributions are studied.

ECE 539 three credits
Electromagnetics of Signal Integrity
3 hours lecture
Prerequisite: ECE 336 or permission of instructor
Electromagnetic fundamentals of signal integrity in high-speed, high-density interconnects. Theory of multi-conductor transmission lines (MTLs) is presented. Per-unit-length capacitance, inductance, conductance, and resistance matrices of MTLs embedded in a multi-layer substrate are introduced and evaluated numerically using the method of moments. Time-domain response of MTLs terminated in arbitrary networks is studied. Circuit-analysis models for MTLs in the Laplace-transform domain are introduced. The effects of signal delay, distortion, cross-talk, ringing, multiple reflections, and losses are discussed.

ECE 540 three credits
Electromagnetics
3 hours lecture
Prerequisite: ECE 336 or permission of instructor
Advanced electromagnetics concepts with in-depth studies of electromagnetic waves, radiation, and scattering. Time-varying electromagnetic fields, electrical properties of matter and electromagnetic theorems are presented. Wave equations are discussed, along with wave propagation, polarization, reflection, and transmission. Multiconductor transmission lines, waveguides, cavity resonators, and radiation and antenna principles are studied. Geometrical optics, diffraction theory, and physical optics are introduced. Topics in scattering include scattering by planar surfaces, cylinders, wedges, and spheres.

ECE 541 three credits
Database Systems I
3 hours lecture
Prerequisites: Graduate standing and at least a C grade in programming
Introduction to database systems from an architectural and functional perspective. The course provides an overview of database systems architecture, computer representation of information, computer data storage, properties of persistent data, database structuring models (relational, network, object, object-relational and entity-relationship), transaction processing models, concurrency control techniques, database and transaction recovery, and security. These concepts will then be explored by examining and comparing the architecture and operations of database systems such as conventional, real-time, temporal, fault tolerant, distributed, heterogeneous, secure and others.

ECE 544 three credits
Fault-Tolerant Computing and Reliability Engineering
3 hours lecture
Prerequisites: ECE 260; MTH 212; MTH 331 or ECE 384; or permission of instructor
Techniques for designing and analyzing dependable and fault-tolerant computer-based systems. Topics addressed include fault, error, and failure cause-and-effect relationships; fault avoidance techniques; fault tolerance techniques, including hardware, software, information, and time redundancy; fault coverage; time-to-failure models and distributions; reliability modeling and evaluation techniques, including fault trees, cut-sets, reliability block diagrams, binary decision diagrams, and Markov models. In addition, availability modeling, safety modeling, and trade-off analysis are presented. The course will also include a research paper and investigation of current topics.

ECE 549 three credits
Network Security
3 hours lecture, 1 hour laboratory
Prerequisite: ECE 469 or permission of instructor
Principles and practices of security in computer networks. This course covers the theoretical foundations of securing computer networks including cryptography and models. It steps through the practical process of defending networking resources. It also reveals various case studies, large and small, to familiarize the students with the techniques that attackers use. An Internet Testbed is facilitated for

Note: Equivalent courses taken elsewhere satisfy undergraduate course prerequisites.

students to experiment attacks and defenses.

ECE 557 three credits
Fundamentals of Acoustics
3 hours lecture supplemented by classroom demonstrations
Prerequisite: Graduate standing; or permission of instructor
Fundamentals of acoustics including vibration and wave propagation in solid and fluid media. Topics include: vibration and wave propagation in one-dimensional, two-dimensional, and three-dimensional media including strings, bars, membranes, plates and fluids; mechanical and electrical equivalent circuit models, separation of variables and normal modes; the development of the homogeneous and inhomogeneous linearized wave equation and solutions; propagation of plane waves and spherical waves in gasses and fluids, derivation of speed of sound for arbitrary fluids, complex sound speed and wave numbers; acoustic impedance, acoustic velocity, acoustic displacement and energy relations; reflection, transmission, refraction, and attenuation phenomena in fluids.

ECE 560 three credits
Computer Systems Performance Evaluation
3 hours lecture
Prerequisites: ECE 460; graduate standing
Development of a broad working knowledge of probability, queuing theory, petri-nets, simulation and empirical modeling as applied to computer systems hardware and software performance modeling and assessment. The course is oriented toward a practical application of theory and concepts with an emphasis placed on the use of computer tools to model performance and to perform trade-off analysis.

ECE 561 three credits
Computer Systems
3 hours lecture
Prerequisites: ECE 161 and ECE 260; or permission of instructor
An examination of various components that make up a computer system, including CPU, memory, input/output, and buses, as well as how they all work together to form a functioning computer system. The major advances in the computer organization and architecture including von Neumann architecture, interrupts, the family concept, microprocessors, cache memory, virtual memory, virtual I/O, pipelining, RISC, superscalar processors, IA-64 (EPIC), micro-programmed control unit as well as parallel processing are also presented. State-of-the-art research projects are assigned to prepare students to perform research in the field of computer organization and architecture.

ECE 562 three credits
Advanced Computer Architecture
3 hours lecture
Prerequisite: ECE 561 or permission of instructor
Advanced computer design, emphasizing fundamental limitations and tradeoffs in designing high performance computer systems. Students develop an understanding of the theoretical foundations in both hardware and software by studying parallel computer models; program partitioning, granularity, and latency; processor architectures and interconnects; and memory hierarchy, interleaving and bandwidth. Specific architectures such as shared memory multi-processors, message passing multi-computers, and superscalar, supervector, VLIW and dataflow designs will be explored.

ECE 565 three credits
Computer Operating Systems
3 hours lecture
Prerequisites: ECE 161 or CIS 215; ECE 257; and ECE 260
Operating system design and implementation using the specifics of current operating systems. Topics covered include: file, process, memory and Input/Output management; multitasking, synchronization, and deadlocks; scheduling and inter-process communication. Projects include system's programming assignments to investigate the kernel interface, files, processes, and inter-process communication for a current operating system.

ECE 566 three credits
Microprocessors I
3 hours lecture
Prerequisites: Graduate standing in the College of Engineering
Design and construction of a microprocessor based computer system. Students will learn how a computer operates at the chip level and develop an understanding of the interdependence of hardware and software. Students will develop circuitry and software to control CPU interaction with SRAM, ROM and peripheral chips, as well as reset and boot-up control and interrupt handling. At the end of the course, students will have produced a working computer.

ECE 567 three credits
Microprocessors II
3 hours lecture
Prerequisite: ECE 566
Design and construction of microprocessor computer systems. This course is a continuation of ECE 566 in which students will either modify the previous design to accommodate multiple processors to achieve parallel computation or explore other modern aspects of microprocessor systems.

ECE 569 three credits
Advanced Computer Networks
3 hours lecture
Prerequisite: ECE 469 or permission of instructor
Advanced topics on the protocols, algorithms, and tools supporting the development and delivery of quality assured services over networks. The course covers capabilities provided by emerging ultra-fast network technologies, routers and routing functions. Emphasis on today's de-facto Internet standards of TCP/IP protocol suite, recent developments and research issues for next generation internetworking driven by multimedia real-time distributed applications requiring quality of service guarantees.

ECE 571 three credits
Digital Communications
3 hours lecture
Prerequisite: ECE 471 or permission of instructor
Fundamentals of digital communications. Topics covered include information theory, vector signal space, detection of digital signals in noise, sampling process, waveform coding techniques, digital modulation and demodulation techniques, error control coding, spread spectrum modulation, and wireless communications.

ECE 574 three credits
Discrete-Time Signal Processing
3 hours lecture
Prerequisites: ECE 384, 475; or permission of instructor
Representation, analysis and design of discrete signals and systems. Topics include a review of the z-transform and the discrete-time Fourier transform, the fast Fourier transform, digital filter structures, digital filter design techniques, quantization issues and effects of finite word-length arithmetic, sampling and oversampling, decimation and interpolation, linear prediction, the Hilbert transform, and the complex cepstrum. Students gain experience in analyzing and designing digital signal processing systems through computer projects.

ECE 575 three credits
Sonar Signal Processing
3 hours lecture
Prerequisites: ECE 521, 597; or permission of instructor
Classical theories in detecting and processing both active and passive signals in noise with special emphasis on the underwater

environment and associated techniques in sound navigation ranging (SONAR). Both spatial and temporal processing methods are studied including beamforming, matched filtering, effects of noise and interference, application and utility of frequency agile signals, narrowband and broadband passive techniques, and adaptive algorithms to address the time/space varying interference sources. Applications in underwater detection, classification, localization, and communication are also discussed.

ECE 577 three credits
Artificial Intelligence
3 hours lecture
Prerequisites: Probability and random variables; or permission of instructor
An introduction to artificial intelligence and expert systems. Topics covered include state-space representations and search methods; problem-reduction representation and search methods; Bayes networks; theorem proving using predicate calculus; natural languages; expert system design using Lisp or Prolog; and an introduction to neural networks and pattern recognition.

ECE 580 three credits
Time Series Analysis
3 hours lecture
Prerequisite: ECE 384 or permission of instructor
Fundamentals of time series analysis. Topics include: moving average and autoregressive models; estimation of the mean and autocorrelation; statistical forecasting; spectral analysis and estimation; bivariate processes; linear system identification; and nonstationary time series. Application to electrical engineering problems is emphasized.

ECE 581 three credits
Mathematics of Systems Analysis
3 hours lecture
Prerequisite: Graduate standing
Elementary exposition of linear algebra and time domain methods and their utility in the analysis and design of linear systems. Linear space, state variables, controllability, observability, assignability, linear state variable feedback design, time variant systems and adjoint model are included.

ECE 582 three credits
Optimal Control Theory
3 hours lecture
Prerequisite: ECE 581
The calculus of variation and classical optimal control techniques based on it. Modern control theory is presented inclu-ding Pontryagin's principle of maximum and Bellman's dynamic programming. Relation to Hamiltonian mechanics is discussed.

ECE 583 three credits
Nonlinear Systems Theory
3 hours lecture
Prerequisite: ECE 581
Analysis and design techniques for nonlinear systems. Topics covered include singular points, contraction mapping, existence and uniqueness of solutions, comparison principle, Lyapunov stability, stability of perturbed systems, slowly varying systems, input-output stability, circle criterion, Popov criterion, small-gain theorem, describing function method, feedback control design via linearization, exact feedback linearization, and other selected topics from nonlinear control theory.

ECE 584 three credits
Estimation Theory
3 hours lecture
Prerequisites: ECE 521, 581
Basic concepts and principles of estimation theory. Topics include least squares estimation, recursive least squares estimation, best linear unbiased estimator, Bayes estimation, maximum likelihood estimation, maximum a posteriori estimation, conditional mean, Gauss-Markov random process, Kalman filtering, prediction, smoothing, and nonlinear estimation. Estimator bounds and properties are discussed.

ECE 587 three credits
Fuzzy Sets and Applications
3 hours lecture
Prerequisites: Probability and random variables; or permission of instructor
Concepts of fuzzy sets, understanding their impact on mathematics, and development of the principles of design. Crisp sets, their operations, and classical two value logic are reviewed and extended to fuzzy sets and fuzzy logic. Relations, orderings, compatibility maps, and morphisms are extended to their fuzzy counterparts. Fuzzy numbers, fuzzy arithmetic and equations are presented. Approximate reasoning, evidence theory, possibility theory and probability are covered. Measures of uncertainty, vagueness, and information are developed. Application to fuzzy control is presented while applications to other disciplines are studied via individualized student projects.

ECE 591 three credits
Topics in Electrical and Computer Engineering
3 hours lecture
Prerequisite: Permission of instructor
Topics of timely interest in Electrical and Computer Engineering. Course content may change from year to year according to instructor's preferences.

ECE 592 three credits
Principles of Project Engineering
3 hours lecture
Prerequisite: Permission of instructor
An introduction to design, scheduling, managing, implementation, and documentation of engineering and applied science projects. The course emphasizes the methodologies that lead to successful execution of projects and the phases and steps of the design process. The course requires the students to practice writing parts of a professional technical document or journal submission. Students work on real engineering tasks and assignments of contemporary importance; these may be work or school related.

ECE 595 three credits
Independent Study
Prerequisites: Submission of a formal proposal that includes grading procedure; approval by the instructor, student's advisor, ECE Graduate Program Director, and department chairperson before the course begins.
Allows study into areas not included in the formal course listings.

ECE 596 three credits
Directed Study
Prerequisite: Permission of the instructor, the ECE Graduate Program Director, and the department chairperson.
Allows completion of a numbered course formally in the graduate program listing but not being offered as a scheduled class.

ECE 597 three credits
Underwater Acoustics I
3 hours lecture
Prerequisite: ECE 557 or permission of instructor
Underwater aspects of sound including a review of the wave equation and its solutions. Topics include: production, propagation and reception of sound underwater, radiation impedance, normal modes in rectangular and cylindrical cavities, acoustic waveguides, group speed and phase speed, introduction to transducers and arrays, beam patterns and aperture functions – Fourier transform pairs, beam steering, The wave equation and its application to boundary value problems are reviewed. The Eikonal equation, velocity profiles in the ocean, ray tracing techniques and propagation models of sound in the sea are introduced. Transmission loss, noise, directivity and the passive and active sonar equations are also developed.

ECE 598 three credits
Underwater Acoustics II
3 hours lecture
Prerequisite: ECE 597 or permission of instructor
A continuation of ECE 597. This course covers advanced aspects of underwater sound propagation including ray, normal mode, parabolic and WKB approximations, shallow water treatments, surface and bottom reflection, scattering theory, reverberation, and ambient and self noise studies.

ECE 599 No credit
Graduate Seminar
Prerequisite: ECE graduate students
Includes instruction in library services, introduction of department faculty research and laboratories, thesis/dissertation requirements, professional ethics and standards, and seminar presentations by speakers from industry and academia in addition to UMass Dartmouth faculty. Students will be required to attend several department seminars and participate in technical discussions and write a report by the end of the semester.

ECE 600 up to six credits
Master's Graduate Project/Thesis
Prerequisite: Submission of a formal proposal endorsed by the student's Graduate Committee
Investigations of a fundamental and/or applied nature, intended to develop design techniques, research techniques, initiative, and self-reliance. For the project option, after three credits, a written project report has to be completed and approved by the student's graduate committee. For the thesis option, after six credits, a written thesis must be completed in accordance with the rules of the Graduate School and the College of Engineering. Admission to the course is based on a formal project/thesis proposal endorsed by the student's graduate committee and submitted to the ECE Graduate Program Director.

ECE 603 three credits
Pre-Dissertation Research
Research for and preparation of doctoral dissertation proposal. The dissertation proposal must provide a thorough survey of the research activities in the research topic area and it must present original and innovative research ideas and preliminary results as well as a defined research scope and directions. PhD students must have passed this course before registering for doctoral dissertation research credits. Graded P/F.

ECE 604 no credits
Doctoral Continuous Enrollment
Prerequisite: ECE PhD students with approval of faculty advisor
PhD students who have completed course credit requirement but not yet passed qualifying exam may take the course with faculty advisor.

ECE 609 three credits
Distributed Computing Architecture
3 hours lecture
Prerequisites: ECE 561, 565
Corequisite: ECE 562
An in depth exploration of the architecture and systems of state-of-the-art distributed computers. Students will develop an understanding of the requirements and design issues associated with high performance computing using networks of commodity computers, including the underlying networking technologies and issues and techniques associated with process scheduling and load balancing. Representative systems will be examined.

ECE 610 three credits
Distributed Computing Programming
3 hours lecture
Prerequisites: ECE 561, 565
Corequisite: ECE 562
An in depth exploration of the issues and methodology in programming distributed computers. Students will develop an understanding of the programming languages and supporting programming environments associated with high performance computing on networks of commodity computers. Representative algorithms and applications will be examined.

ECE 611 three credits
Current Topics in Distributed Computing
3 hours lecture
Prerequisites: ECE 561, 565
Corequisite: ECE 562
A survey of issues and methodology in programming distributed computers. Students will develop an understanding of the hardware and software used in high performance computing based upon networks of commodity computers. Representative systems, algorithms, and applications will be examined.

ECE 631 three credits
Database Systems II
3 hours lecture
Prerequisite: ECE 541
An in depth view of database management systems architecture and operations. The focus is on architectural and operational aspects of transactions and transaction processing. Topics include properties of data in a database, database management systems architecture, transaction properties, transaction processing, transaction and database recovery, concurrency control, locking protocols, storage management, and the application of concepts within various database systems. The course includes a design project derived from topics covered.

ECE 632 three credits
Advances in Database Systems
3 hours lecture
Prerequisite: ECE 541
An in depth exploration of the theory, architecture, implementation and design of state-of-the-art specialized data base systems. Students will develop an understanding of the requirements and design issues associated with emerging technologies applied to specialized database systems. Database systems to be studied will be selected based on present research interest of course faculty and students.

ECE 640 three credits
Wavelets
3 hours lecture
Prerequisites: ECE 574 and graduate standing; or permission of instructor
Basic theory and applications of wavelets and filter banks. Wavelet theory provides very general techniques that can be applied to many tasks in signal processing, e.g., multi-resolution analysis in computer vision, subband coding in speech and image compression, and wavelet series expansions in applied mathematics. The course is designed to enable participants to understand wavelet theory and to acquire a working knowledge of the techniques available in this signal processing area. In particular, a paramount goal is to enable each participant to develop a critical understanding of the advantages and limitations of wavelet analysis.

ECE 642 three credits
Advanced Topics in Signal Processing
3 hours lecture
Prerequisites: ECE 521, 574
Advanced signal processing topics. Content may vary according to instructor's preferences but typically includes selections from: two-dimensional signal processing, higher-order spectral analysis, chaotic signal processing, array signal processing, multirate signal processing, optimal filtering and linear prediction, time-frequency and time-scale signal analysis, smart antennas, and inverse problems (signal reconstruction). Applications are discussed in radar, sonar, acoustics, speech, communications, and image processing.

ECE 644 three credits
Adaptive Filtering
3 hours lecture
Prerequisites: ECE 521 and ECE 574
Basic theory of adaptive filter design and implementation including applications. Topics include optimal filters, adaptive linear combiners, performance measures, adaptive FIR filters, adaptive IIR filters, and nonlinear adaptive filters. Applications in adaptive signal processing include adaptive modeling and system identification, adaptive deconvolution and equalization, and adaptive interference canceling.

ECE 646 three credits
Digital Speech Processing
3 hours lecture
Prerequisites: ECE 521, ECE 574, and graduate standing
Signal processing and statistical techniques used in processing speech signals providing an understanding of how these techniques are used in the coding, synthesis and recognition of speech. Topics typically include the human vocal and auditory systems, characteristics of speech signals, lossless tube model of speech production, time and frequency domain representations of speech, time-frequency speech analysis methods, homomorphic speech processing, speech coding, speech synthesis, speech recognition, pitch detection and processing, and acoustic preprocessing for speech recognition.

ECE 669 three credits
Computer Network Management
3 hours lecture
Prerequisite: ECE 569 or permission of instructor
Advanced topics in computer networks. Topics include: network management systems and architectures; network management protocols and standards; management of information bases. Examples are drawn primarily from the Internet (e.g., SNMP).

ECE 671 three credits
Information Theory
Prerequisite: ECE 521, 571
Fundamental aspects of information theory. Topics include discrete and differential entropy, discrete source and channel model, information rate, mutual information and channel capacity, coding theorems for sources and channels, the data processing theorem, encoding and decoding of data for transmission over noisy channels, rate distortion theory, maximum entropy distributions, and entropy estimation techniques for unknown sources. Several applications of information theory are included.

ECE 672 three credits
Signal Detection Theory
3 hours lecture
Prerequisites: ECE 521, 571
Fundamentals of detection theory. Topics include Bayes and Neyman-Pearson tests, composite hypothesis testing, nonparametric test, detection of known signals in Gaussian noise, detection of signals with random parameters in noise, multiple pulse detection of signals, generalized likelihood ratio test, Bayes and maximum likelihood estimators, comparison of communication systems, space-time processing, application to radar and sonar.

ECE 673 three credits
Pattern Recognition
3 hours lecture
Prerequisite: ECE 521
An introduction to the theory and applications of pattern recognition. Topics include descriptions of patterns, problem formulation, linear and nonlinear classification theories, representation of patterns, feature selection, supervised and unsupervised training, nonparametric methods in pattern recognition, cluster and mode-seeking techniques, recursive algorithms using stochastic approximation, sequential pattern recognition, design of computer recognition experiments, linguistic approach to pattern recognition.

ECE 674 three credits
Time-Frequency Signal Processing
3 hours lecture
Prerequisites: ECE 574 and graduate standing; or permission of instructor
Time-varying signal processing methods. The course covers many of the prevalent techniques that have been developed over the years for time-frequency signal analysis and addresses the characteristics and properties of time-frequency representations in Cohen's fixed kernel class, e.g., the spectrogram and the Wigner distribution. The course covers many time-frequency representations and addresses their performance tradeoffs in applications.

ECE 675 three credits
Sonar Systems Engineering
3 hours lecture
Prerequisites: ECE 521, 597; or permission of instructor
Principles and design of sonar systems. Topics include: complex array and element apertures (weighting) functions, and beam shaping; linear, planar, and volumetric arrays; directivity and beam-forming; operating and installation of sonar systems; improving signal-to-noise ratios; wave vector spectrum filtering.

ECE 677 three credits
Neural Networks
Prerequisites: ECE 521
Theory of neural networks. Topics include learning models, single and multilayer perceptrons, LMS algorithm, back propagation algorithms, radial basis function networks, Hopfield networks and Boltzman machine, self-organizing systems including Hebbian learning, Kohonen feature map algorithm, temporal processing neural networks, biological neural networks, and VLSI implementation.

ECE 678 three credits
Digital Image Processing
3 hours lecture
Prerequisites: ECE 521, 574
Fundamentals of digital image processing. Topics include human vision models, 2-D sampling and quantization, image transforms, image enhancements, color image processing, image restoration, image and video compression, image segmentation by thresholding and region analysis, texture analysis, boundary descriptions, morphological methods, image processing system architecture.

ECE 679 three credits
Geophysical, Radar, and Speech Signal Processing
3 hours lecture
Prerequisites: ECE 521, 574
Common mathematical frameworks in the processing of geophysical, radar, and speech signals are introduced, followed by a study of individual source mechanisms and transmission media. Specific digital filtering, deconvolution, spectral analysis and interference or clutter rejection techniques are discussed. Case studies for effective processing of seismic, radar, and speech signals are also included.

ECE 680 three credits
Computer and Robot Vision
3 hours lecture
Prerequisites: ECE 678 or permission of instructor
Conditioning and labeling, the facet model, texture models, image segmentation and arc extraction, 3-D shape representation and shape recovery, surface reflection mechanism, shape from shading, range image analysis, stereo vision, 2-D and 3-D motion analysis, non-rigid body motion analysis, relational matching, 3-D object recognition, fundamentals of robot vision, architecture of computer vision systems.

ECE 697 three credits
Nonlinear Acoustical Theory
3 hours lecture

Prerequisite: ECE 597
Nonlinear acoustic fields and parametric sources. Topics include nonlinear acoustics of fluids, turbulence, underwater explosions as sources of sound, parametric acoustic arrays, finite-amplitude effects, acoustic cavitation, and streaming.

ECE 699 three credits
Acoustic Transduction and Electroacoustic Transducers
3 hours lecture
Prerequisite: ECE 557, 597
An advanced course covering fundamental principles, design, and operation of transducers for the reception and generation of underwater sound using energy analysis methods. Topics include: theory of simple radiators and receivers, electromechanical circuit analogies, impedance functions and equivalent circuits; piezoelectricity; reciprocity; acoustic properties of transducer materials; acoustic motion sensors; pressure gradient sensor designs, and diffractions constants.

ECE 700 one credit
Advanced Graduate Seminar
Prerequisite: Graduate standing
Seminar discussions and presentations based on research or detailed literature surveys.

ECE 701 up to nine credits
Doctoral Dissertation Research
Prerequisites: Successful completion of PhD comprehensive examination and approval of doctoral dissertation proposal by the student's graduate committee
Investigations of a fundamental and/or applied nature representing an original contribution to the scholarly research literature of the field. PhD dissertations are often published in refereed journals or presented at major conferences. A written dissertation must be completed in accordance with the rules of the Graduate School and the College of Engineering. Admission to the course is based on successful completion of the PhD comprehensive examination and submission of a formal proposal endorsed by the student's graduate committee and submitted to the ECE Graduate Program Director.