Electrical and Computer Engineering

Student Handbook
2018-2019
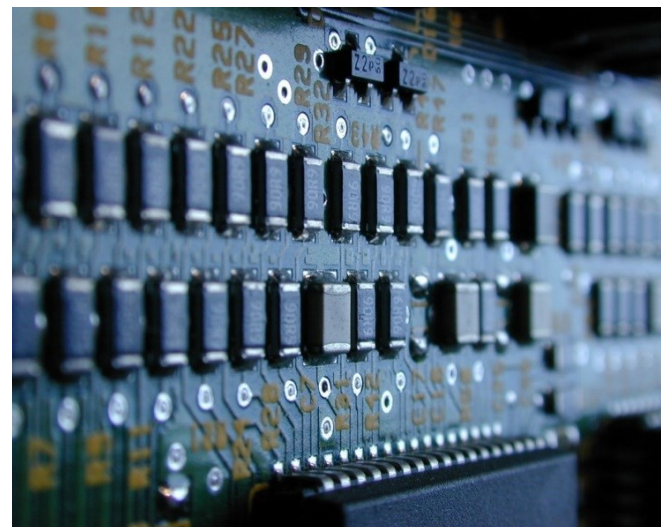
Dept. of Electrical and Computer Engineering

University of Massachusetts Lowell
One University Ave
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Lowell, MA 01854
(978) 934–3300 Fax: (978) 934-3027
web page: www.uml.edu/Engineering/Electrical-Computer/

Academic Schedule- Fall 2018

Sep. 1	Residence halls open for new students
Sep. 2	Residence halls open for returning students
Sep. 3	Labor Day (university closed)
Sep. 4	Convocation
Sep. 5	Fall classes begin. Drop-add period begins.
Sep. 11	Last day for undergraduate students to add a course without a permission number. Last day for instructors to publish course and attendance requirements for class members.
Sep. 18	Last Day to (1) Add a course with a permission number (2) Drop a course without record (3) Change enrollment status from: Audit to Credit; Credit to Audit; "Pass-No Credit" to Letter Grade; Letter Grade to "Pass-No Credit" Note: **No Refunds after this date**
Oct. 8	Columbus Day (University Closed)
Oct. 11	Monday Class Schedule
Oct. 17	Mid-Semester: at least one evaluation required in each course
Oct. 22	Faculty advising period begins. Students check SiS for enrollment appointments. First day for seniors who anticipate completion of degree requirements by the end of May or the end of August to confer with faculty advisors and to file Programs of Baccalaureate Studies (DIG form).
Oct. 29	Enrollment for spring 2019 courses begin using enrollment appointment dates obtained from student SiS self-service. Last day for students to complete work for incomplete spring semester and summer session (2018) courses.
Nov. 5	Faculty advising period ends; Last day for seniors who anticipate completion of degree requirements by the end of May or the end of August to confer with faculty advisors and to file programs of baccalaureate studies (DIG form).
Nov. 12	Veterans Day (university closed)
Nov. 14	Last Day for Students to withdraw from courses with grade of "W." All other sessions see OCE calendar.
Nov. 21	Thanksgiving recess
Nov. 26	Classes resume
Dec. 6	No hour examination shall be administered during the last five academic days of the semester unless exemption has been allowed by the college dean.
Dec. 13	Last day of fall semester classes; Last day for faculty to file grades for incompletes and change of course grades for spring semester (2018) courses
Dec. 14	Reading Day (no classes or exams)
Dec. 15	Fall semester examinations begin (There will be Sat. exams)
Dec. 21	Fall semester examinations end 6:00PM; Residence halls close at 6:00PM
Dec. 22	Make-up day for examinations postponed because of Weather; Winter Recess Begins
Dec. 27	Deadline for final grades to be recorded in SIS by 4p.m.
	Note: In the event that examination days are postponed because of weather conditions, the first day of postponed examinations will be made up on December 22, December 24. Additional postponed examination days will be made up on January 18.

Academic Schedule - Spring 2019

Jan. 20	Residence halls open at Noon
Jan. 21	Martin Luther King Day (university closed)
Jan. 22	Spring classes begin; drop-add begins.
Jan. 28	Last day for undergraduate students to add a course without a permission number.
	Last day for instructors to publish course and attendance requirements for class members.
Feb. 4	Last day to: (1) Add a course with a permission number; (2) Drop a course without record; (3) Change enrollment status from: Audit to Credit; Credit to Audit; "Pass-No Credit" to Letter Grade, or Letter Grade to "Pass-No Credit". **Note: No refund after this date.**
Feb. 18	Presidents Day (university closed).
Feb. 19	Monday class schedule
Mar. 5	Mid-semester: at least one evaluation required in each course.
Mar. 11	Spring recess
Mar. 18	Classes resume
Mar. 25	Last day for students to complete work for incomplete fall 2017 courses
Mar. 29	Fall 2019 schedule of classes will be viewable in SiS
Apr. 2	Faculty advising period for fall 2019 begins.
	First day for seniors who anticipate completion of degree requirements by the end of December 2019 to confer with faculty advisors and to file Programs of Baccalaureate Studies (DIG form).
Apr. 9	Last Day for Students to withdraw from courses with grade of "W". All other sessions see OCE calendar.
Apr. 10	Enrollment for fall 2019 courses begin using enrollment appointment dates obtained from student SiS self-service.
Apr. 15	Patriot's Day (university closed)
Apr. 16	Faculty advising period for fall 2018 ends. Last day for seniors who anticipate completion of degree requirements by the end of December 2019 to confer with faculty advisors and to file Programs of Baccalaureate Studies (DIG form).
Apr. 19	Monday class schedule
Apr. 26	No hour examination shall be administered during the last five academic days of the semester unless exemption has been allowed by the college dean.
May 3	Last day of spring semester classes; Last day for faculty to file grades for incompletes and changes of course grades for fall 2018 courses.
May 4	Reading Day (no classes or exams)
May 6	Spring semester examinations begin (there will be Saturday exams)
May 11	Spring semester examinations end at 6 p.m.
	Residence halls close at 6 p.m.
May 13	Make-up day for examinations postponed because of weather.
May 14	Deadline for final grades to be recorded in SiS by 4 p.m.
May 18	University Commencement

Revised Sep-21-17

Welcome

Welcome to the Electrical and Computer Engineering (ECE) Department at the University of Massachusetts Lowell. This handbook is a resource for both current and prospective students. Our department offers a diverse curriculum at both the undergraduate and graduate levels. Bachelor and Master degrees in engineering are offered in both Electrical Engineering and Computer Engineering. Our graduate program also offers a doctorate in engineering in Electrical Engineering and Computer Engineering. Our team of experienced faculty has active research programs in a variety of specialization areas including telecommunications, microwave technology, optoelectronic devices, digital signal processing, wireless communications, power distribution, alternative energy sources, nanotechnology, embedded computing, and networking. Our facilities include numerous laboratories and five research centers that span diverse areas of electrical and computer engineering, enabling research at both the graduate and under-graduate level.

Please feel free to contact us with any questions about our program.

Professor Martin Margala, ECE Department Chair

Office of Undergraduate Admissions
University of Massachusetts Lowell
Dugan Hall Rm 110
883 Broadway St. Lowell MA 01854-5104
(800) 410-4607 or (978) 934-3931 Fax (978) 934-3086
email: admissions@uml.edu
web page: www.uml.edu/Admissions

Office of Student Financial Assistance
University of Massachusetts Lowell
McGauvran Student Center, Suite 7
71 Wilder Street
Lowell, MA 01854-3089
(978) 934-4220 Fax (978) 934-3009
email: see web site for list of counselors
web page: www.uml.edu/admin/finaid

Office of Residence Life

University of Massachusetts Lowell
Cumnock Hall
One University Avenue
Lowell, MA 01854
(978) 934-2100 Fax: (978) 934-3042
web page: www.uml.edu/student-services/reslife

The Graduate School
University of Massachusetts Lowell
Dugan Hall
883 Broadway St., Lowell MA 01854
(800) 656-GRAD or (978) 934-2381 C Fax 978 934-3010
email: Graduate_School@uml.edu
web page: www.uml.edu/grad

College of Engineering
University of Massachusetts Lowell
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REVISED ADMISSIONS STANDARDS for College of Engineering as of 11/25/2008

The University Admissions Office uses a common minimum admissions standard established by the Commonwealth of Massachusetts Board of Higher Education for the University of Massachusetts. There are different standards for Freshmen applicants, Transfers, Non-traditional and Special Admissions.

The College of Engineering sets additional criteria over and above these minimum standards. In addition, the Admissions Office considers high school class rank, SAT-I totals and high school GPA, and assigns a numeric value to each student based on an aggregate of the above three criteria. The following are the minimum admissions standards for First Year students to the College of Engineering:

- Minimum weighted HS GPA of a 2.75 on a nominal 4.0 scale
- Minimum combined SAT I Math + Critical Reading total score of 1000 (max 1600)
- Minimum weighted average of grades from all HS math and physical science courses (Physics, Chemistry) of 2.50 on a 4-point scale
- Math proficiency as evidenced by one or more of the following:
  - Sufficient HS math courses to allow entry into 92.131 Calculus I during first semester (students should have taken & passed Algebra I, Algebra II, Geometry and either Trigonometry, Pre-calculus or Calculus) OR
  - Minimum score of 3 or more (out of 5) on the Advanced Placement Calculus AB or BC exam
  - OR
  - College-level Calculus I with grade of C or better
- At least 3 natural science courses (Chemistry, Physics, Biology, Earth Sciences, Anatomy & Physiology), two of which must have a lab component, AT LEAST ONE of which is either HS Physics or Chemistry. It is STRONGLY recommended that applicants in Engineering have BOTH Physics and Chemistry.
- At least 16 academic courses, all of which must be at the College Prep level or higher

Exceptions: When applicants show a SAT M+V score less than 1000 or HS GPA below 2.75, they will be considered for admissions according to the following sliding scale:
- if HS GPA between 2.50 and 2.75, SAT M+V must ≥ 1100
- if HS GPA <2.50, SAT M+V must ≥ 1200
- if SAT <1000, GPA must ≥ 3.0

Students who do not meet these minimum standards for the College of Engineering and are admitted initially to the University in Colleges other than Engineering) will only be allowed admission to the College of Engineering AFTER they have successfully passed 92.131 Calculus I or equivalent with a minimum "C" grade AND only after they have successfully completed at least one full semester at UMass Lowell as a full-time student with a GPA of at least 2.0. Students who meet these criteria may file a petition to change majors which requires the consent of the Department Chair and Dean of the College into which the student is transferring.

Some students may be a eligible for the Patricia Goler Fellows Program, which provides a structured plan for a limited number of freshmen who are first in their families to attend college and/or whose family earnings are less than 150% of the statewide poverty level. Eligible students must have earned a GPA of 2.5, and a minimum combined SAT of 850. Students in this Program who wish to enroll in Engineering must meet the minimum criteria for admissions or transfer into Engineering.

Students admitted into the College of Engineering may declare a Departmental affiliation at the time of admission, although there is no requirement for them to do so until the end of their Freshman year. Transfer students are admitted using a different set of Admission standards:

- Students with 12-23 transferable college credits and a minimum 2.5 college GPA
- Students with 23 transferable college credits, a minimum 2.0 college GPA, and a high school transcript which meets the admissions standards for freshmen applicants
- Students with 24 transferable credits and a minimum 2.0 college GPA.

The Office of Admissions determines whether or not courses taken elsewhere are eligible for transfer and conducts a preliminary evaluation. The University of Massachusetts Lowell subscribes to the Commonwealth Transfer Compact and Joint Admissions Programs. In addition, the applicants' records are individually evaluated by each department's transfer coordinator to determine whether or not they fulfill departmental program requirements. For more information, go to UMass Lowell Office of Undergraduate Admissions.

Department Administration

Department Chairman... Martin Margala   Ext. 42986
Associate Chairman .... Jay Weitzen   Ext. 43315
Graduate Coordinator .... Xuejun Lu   Ext. 43359
Undergraduate Committee Chairman .... Jay Weitzen   Ext. 43315
Transfer Coordinator... Jay Weitzen   Ext. 43335
Doctoral Coordinator.. Alkim Akyurtlu   Ext. 43336
Co-Op Program Coordinator .... Martin Margala   Ext. 42986
Main University Number .... (978) 934-4000

Faculty and Staff Directory

(see UMass Lowell building codes for exact office locations)

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Department Support Personnel

Staff Assistant .... Ruth Dubey-Leduc, Ext. 3306
Technical Staff .... Senait Haileselassie, Ext. 3331
ECE Lab Manager .... Dohn Bowden, Ext. 3514

Electrical and Computer Engineering at UMass Lowell

Electrical and Computer Engineering are dynamic fields, advancing as a result of breakthroughs in technology as well in the pure sciences. Because engineering disciplines continuously incorporate new concepts and developments, a viable engineering education cannot be limited to the acquisition of specific skills and methods, but must also provide the student with a deep understanding of both the current and the emerging engineering fields.

The ECE Department is well placed to help fulfill the campus' role within the University of Massachusetts system. The faculty embraces the mission of serving a technologically oriented Department, closely linked to regional and national industry.

ECE Mission Statement

University: "The Mission of the University of Massachusetts Lowell is to provide to students an affordable education of high quality and to focus some of its scholarship and public service on assisting sustainable regional economic and social development."

College of Engineering: The Francis College of Engineering seeks to prepare men and women to be successful in engineering or their chosen profession. The faculty and staff of the Francis College of Engineering are strongly committed to providing our students with a high quality education relevant to the needs of society and industry. We will do this in a cooperative atmosphere that facilitates learning and cares about the needs of our students.

ECE Department: The ECE Department mission for undergraduate education is to provide a thorough grounding in electrical science, electrical engineering, and computer engineering, together with an intensive training in mathematics. The techniques of experimental science and technology are emphasized through investigative laboratory work and classroom lecture/demonstrations.

The curriculum includes engineering science and design courses that provide a balanced view of hardware, software, application trade-offs and the basic modeling techniques and the use of computer aided design tools. Such experiences are integrated throughout the curriculum and are designed to encourage each student to engage in a major and meaningful design experience. An important aspect of the ECE curricula is the technical elective program of the senior year. Technical electives provide opportunities for both broadening and deepening technical knowledge according to student interests and competencies. Double majors in Computer Science and Physics are also offered. The capstone project is organized to bring together knowledge from several courses to solve a real-world engineering problem. The ECE Department also cooperates with many local companies, both large and small, in order to offer co-op opportunities for which course credit can be earned.

The ECE Department strives to be a Department of choice for both local and regional students and is actively repositioning itself. We have responded to industry needs by offering focused programs both at the undergraduate and graduate levels in order to develop technically literate engineers of value to the community. Our graduates are knowledgeable and practical problem solvers, most of whom stay in the New England area as working engineers.

Research assistantships are available through special arrangements with individual research advisors. Individuals interested in research assistantships should contact departmental faculty members concerning the availability of this form of financial aid. Students who receive teaching or research assistantships must be matriculated and full-time (minimum of 9 credits/semester).

The amount of the Teaching or Research Assistantship for each semester or academic year is set according to agreement between UMass Lowell and the UAW/Graduate Employees Organization. For in-state students, a full or half-time Assistantship carries a taxable stipend plus a full tuition and fees waiver for each semester. For out-of-state students, a full or half-time Assistantship carries the same taxable stipend as the in-state students, plus a full out-of-state tuition waiver. However, the out-of-state student is still responsible for any fees.

Teaching & Research Assistantship Stipend/Waiver Information:

(for full year, double the amounts shown)

Item	half-time	TA/RA per semester	full-time	TA/RA per semester
	in-state	out-of-state & foreign	in-state	out-of-state & foreign
stipend	$3,349	$3,349	$6,504	$6,504
total TA/RA value per semester	$7,611	$8,480	$12,265	$16,199

Education Costs - Full time (9 credits) per year:

In-state: $10,704 Out of state: $19,804

New England Regional & New England Proximity: $7,380

The ECE Department has long been known throughout the region for producing competent "hands-on" engineers who are the mainstay of the region's industries. For example, Raytheon, a major employer in the region, has more University of Massachusetts Lowell EE and CpE graduates than from any other Department in the country. We value this reputation and, in concert with industry's needs but without compromising the long term value of the educational needs, we strive to maintain and enhance this image. The ECE Department offers a co-op program which the College of Engineering and the University have helped to formalize. We believe that making such opportunities available to students greatly enhances their experience of engineering both with respect to the relevance of our courses as well as the exposure to working with other professionals.

The ECE Department has also developed a project-based Capstone program for seniors that is designed to provide support to the disabled. Many electronic and microprocessor based systems have been delivered that have made a major impact on the freedom and quality of life for the disabled.

A portion of the curriculum for ECE students is also devoted to studies in the humanities and social sciences and a wide choice of subjects is allowed. These General Education (GenEd) courses serve to broaden the student's outlook and focus attention on the importance of non-technical knowledge in determining the student's ultimate level of responsibility in professional life.

Local industry is our main constituency. Most of our students enter industry and a significant percentage find positions at companies within 100 miles of Lowell. While some go to graduate school directly, our typical graduates go directly into the workforce with the expectation that the employer will fund their graduate school education. Since the majority of our graduate student body is part time, our graduate courses are offered in the evenings, enabling students to take one or two courses per semester.

The ECE Industry Advisory Board plays an important role in considering our program objectives by providing us immediate industrial needs. Input from our advisory board serves to continually assess the relevancy of the curriculum to the needs of industry. These needs must be balanced against the need to deliver fundamental knowledge that will enable our graduates to evolve with the latest technological advances. Technical areas sometimes take second place to a "can-do" attitude, excellent communication skills, and the initiative required to teach oneself. Meetings with our Industry Advisory Board occur once per semester. Our close ties with industry through the co-op program, research and consulting, and alumni interactions provide valuable feedback on our program with respect to the skill sets required to function in a working environment.

Strategic alliances have been formed with several of our Industry Advisory Board members. For example, Analog Devices has funded a scholarship program that provides four undergraduate ECE students a guaranteed internship during the winter and summer vacations. A pipeline of co-op students is in place with several companies, providing for very close interaction and feedback between our programs and their expectations. Ten other companies have since joined the Scholar-Intern program, offering scholarships to prospective ECE students.

Although department's primary focus is undergraduate education, our graduate program leverages the strengths of the department faculty and complements the undergraduate program. Our faculty have close ties with local and regional industry through consulting and research. Our professors also advise graduate students from regional companies, and participate in local and national professional societies and organizations.

Research Centers and Laboratories

The ECE Department is both nationally and internationally recognized for its research in several areas, such as alternative power sources, electromagnetic scattering, electro-magnetic materials, photonics, acoustics, signal processing, networking, and imaging.

The ECE Department maintains several Research Centers including:

- Advanced Electronics Technology Center
- Center for Advanced Computation and Telecommunications
- Center Computer Man/Machine Intelligence, Networking & Distributed Systems
- Center for Electric Cars and Energy Conversion
- Center for Electromagnetic Materials and Optical Systems

Research is also supported by many laboratories including:

- Advanced Digital Systems Design and Microprocessors Laboratory
- Battery Evaluation Laboratory
- Computer Architecture Laboratory
- Distributed Integrated Semiconductor Processing Laboratory
- Electric Vehicle Laboratory
- Electromagnetic and Complex Media Laboratory
- Imaging and Informatics Laboratory
- Microwave Anechoic Chamber Facility
- Networking, Artificial and Machine Intelligence and Computer Vision Laboratory
- Renewable Energy Laboratory
- Raytheon Microwave Laboratory
- Converged Networking Laboratory

Instructional Laboratories

The department maintains several laboratories that are oriented at instructional activities. Many of these labs have been established with the support of local companies. These labs include:
- Raytheon Microwave Laboratory
- Sun Microsystems Cadence VLSI Design Laboratory
- Analog Devices Analog Electronics Laboratory
- EST/Wind River Laboratory for embedded microprocessor programming
- Sun Microsystems Information Security Laboratory for the investigation of hardware, software, and embedded solutions targeting secure applications.
- Capstone Project Laboratory, for assistive technology projects.
- Sophomore Circuits Laboratory
- Junior Electronics Laboratory
- Virtual Instrumentation Laboratory

Cost & Financial Aid

Undergraduate

UMass Lowell is value; for 2012-2013 tuition and fees, room & board for in-state full-time undergraduate students is only $20,817 for 1 academic year. Tuition and fees alone cost; $11,297 for in-state students, $17,350 for out-of-state students.

Graduate

The total cost of attending Graduate School depends on the residency status of the student - whether Massachusetts resident (at time of application), New England Regional resident (if there is no comparable program in the student's own New England state), or out-of-state (including foreign students). The cost is dependent upon number of credit- hours registered in a given semester, up to "full time" status of 12 credit-hours. The cost consists of two major items, tuition and fees, which can be obtained from the Graduate School website.

A limited number of Teaching and Research Assistantships are available for qualified full time graduate students. These positions are assigned by the student's department and are subject to the agreement between UMass Lowell and UAW/Graduate Employees Organization. Therefore, all requests for teaching assistantships should be directed to the Departmental graduate coordinator or chairperson. Historically, many full time graduate students in the Department of Chemical Engineering have received either a full or half- time Assistantship at some point in their graduate program. Note, however, that this is not a guarantee of support for all full time students.

A student who signs a teaching assistantship contract after April 15th is legally bound to honor this agreement and may not accept an offer from another institution, in accordance with the 1988 Council of Graduate Schools resolution governing this matter. Students interested in receiving an assistantship should file their applications for admission to a degree program as early as possible, checking the appropriate box on the application form. A student who is to receive an assistantship will be notified and sent a contract directly by the department. Reappointments in succeeding years are contingent upon satisfactory performance of duties as well as academic achievement. Master's degree candidates may hold an assistantship for a maximum of two years and doctoral candidates for a maximum of four years.

To ensure that teaching assistantships are awarded to the most qualified individuals, the Graduate School has established the following requirements:

1. No teaching/research assistantship may be awarded to a graduate student with incompletes, F's, or U's on his or her transcript.
2. No teaching/research assistantship may be awarded to a graduate student with a cumulative grade point average under 3.0 on the official transcript.
3. No university-funded teaching/research assistantship may be awarded to a master's degree candidate if he/she has completed the total number of credits required for his/her program.
4. Level 3 teaching/research assistantships may only be awarded to graduate students who have reached doctoral candidacy (i.e. completed all course work, oral/written and language examinations) and are enrolled in dissertation research.

Vinod Vokkarane

B.S.	University of Mysore, India
M.S.	University of Texas Dallas
Ph.D	University of Texas Dallas

Research Interests: The design, analysis, and modeling of architectures, protocols, and algorithms for ultra-high speed networks, such as Optical networks, Grid/Cloud networks, and Big-data networks. He has been funded by NSF, DOE, USMC and industry.

Xingwei Wang

B.S.	Zhongshan (Sun Yat-sen) University, Guangzhou, China
M.S.	Virginia Tech
Ph.D	Virginia Tech

Research Interests: Optical biosensing and biomedical devices; nanoprobe design and fabrication; self-assembled nanostructures; electromagnetic wave propagation; temperature, pressure, acoustic, strain, and chemical sensors.

Jay A. Weitzen

B.S.	University of Wisconsin, Madison
M.S.	University of Wisconsin, Madison
Ph.D	University of Wisconsin, Madison

Research Interests: Wireless communication systems, digital communication systems, navigation and position systems.

Thanuka Wickramarathne

B.S.	University of Moratuwa, Sri Lanka
M.Sc.	University of Miami
Ph.D.	University of Miami

Research Interests: Signal Processing for Big-Data, Distributed Dynamic Inference, Cybernetics, Complex Networks

Hengyong Yu

B.S.	Xi'an Jiaotong University, China
B.E.	Xi'an Jiaotong University, China
Ph.D	Xi'an Jiaotong University, China

Research Interests: medical image reconstruction, computed tomography, medical imaging methods and systems, medical image processing and analysis, biomedical informatics.

Hualiang Zhang

B.S.	University of Science and Technology of China
Ph.D.	Hong Kong University of Science and Technology

Research Interests: RF/microwave/millimeter-wave circuits, components and systems, metamaterials, nano-photonics, antenna design, transformation optics, graphene-based electro-optic devices.

Undergraduate Programs

The ECE Department offers two undergraduate degrees, a B.S. Eng. in Electrical Engineering and a B.S. Eng. in Computer Engineering. The ECE Department also offers opportunities for double majors with Computer Science (CS) and Physics. Detailed programs of study for these double majors are described later in this handbook.

All undergraduate students are assigned faculty advisors and students are required to meet with their advisors, during registration periods or anytime there is some matter of concern. Students should consult with their advisor on the best path through their chosen track. This is especially true for co-op and part-time students, since the need to adhere to prerequisite course requirements is very important. The programs of study for each degree are described below.

Focus Areas

The ECE Department has five technology focus areas:

- Computer Engineering
- Electrical Power and Energy Engineering
- Electromagnetic and Electromagnetic Properties of Materials
- Micro- and Optoelectronic Materials, Circuits and Systems
- Telecommunications and Information Engineering

Program Objectives

Specific program objectives in support of our undergraduate educational mission are that after 4-5 years of experience, our graduates should:

1. Be established and recognized as a valued professional and effective communicator in industries related to electrical, computer and electronic technologies.

2. Practice their profession in a collaborative, team-oriented manner that embraces the multidisciplinary and multicultural environment of today's business world.

3. Engage in lifelong learning and professional development via post graduate education and participation in professional organizations.

4. Function as a responsible member of society with willingness to mentor fellow employees and an understanding of the ethical, social and economic impact of their work in a global context.

Program Outcomes and Assessment

Given our student body and our particular constituencies, our program outcomes can be summarized as follows:

When a UML ECE student graduates he/she shall have:

1. A strong grounding in the fundamentals including the ability to formulate and solve engineering problems by applying the principles of mathematics, science and electrical & computer engineering.

2. Ability to analyze and synthesize engineering problems including design and conduct experiments, use standard test equipment and interpret experimental data.

3. Ability to design reliable systems, devices or processes from initial specifications to a deliverable system.

4. Ability to work in a multidisciplinary team environment.

5. Ability to communicate effectively in both verbal and written forms.

6. Ability to appreciate the complexities of professional environments, including taking responsibility for oneself, working effectively and professionally as a team member, and being mindful of ethical, economic, and contemporary concerns.

7. Competence in taking the initiative for one's own professional development and recognition of the need and ability in engaging in post graduate education and lifelong continual learning.

8. Ability to independently accomplish engineering tasks

9. Ability to enter industry with the engineering techniques, skills, and tools required to be able to solve real-world problems in electrical and computer engineering.

General Education Requirements

Students are required to take three Social Science courses and two Art and Humanities chosen from the list in the schedule book. General Education courses are identified in the "Gen. Ed" column in the curriculum plans with appropriate designations. Courses must have a complete course number listed in the University Course Schedule Book to be accepted. Further information regarding General Education courses can be found in the University Course Schedule Book and at http://www.uml.edu/gened.

Tenneti C. Rao

B.Sc.	Andhra University
B.E.	Indian Institute of Science, Bangalore
M.E.	Indian Institute of Science, Bangalore
Ph.D.	Indian Institute of Science, Bangalore

Research Interests: Novel transmission line and waveguide structures for millimeter wave propagation; Development of new analytical tools to analyze monostatic and bistatic scattering cross sections from a terrain covered with snow or vegetation.

Seung Woo Son

B.S.	Yeungnam University, South Korea
M.S.	Yeungnam University, South Korea
Ph.D	The Pennsylvania State University

Research Interests: High performance computing, parallel computing, data-intensive computing, machine learning, computer architecture, compilers, embedded systems

Jianxin Tang

B.S.	Electrical Engineering, Guangxi University
M.S.	Electrical Engineering, University of Bridgeport
Ph.D.	Electrical Engineering, University of Connecticut

Research Interest: Digital signal processing with applications to real-time digital filtering, communication, and control.

Joel Therrien

B.S.	UMass Lowell (Physics)
M.S.	UMass Lowell (Energy Engineering)
Ph.D	University of Illinois Urbana-Champaign (Physics)

Research Interests: Nanoscale sensors, nanoelectromechanical devices, chemical/biological sensors, optoelectronics. Scanning Probe Microscopy for nanomanufacturing, nanomanufacturing methods for electronic devices.

Charles Thompson

B.S.	New York University
M.S.	Polytechnic Institute of New York
Ph.D	Massachusetts Institute of Technology

Research Interests: Physical acoustics, computational modeling, nonlinear systems, telecommunications.

Frank Tredeau

B.S.	Northeastern University
M.S.	UMass, Lowell
Ph.D	UMass, Lowell

Research Interests: Power Conversion, Battery Management, Power Electronics, Electric Vehicles

Martin Margala

B Dipl. Ing.	Slovak Technical University, Slovakia
Ph.D.	University of Alberta, Canada

Research Interests: Low-power memories, adaptable circuits and architectures, SIMD and MIMD processing, analog-to-converter design, design for reliability, multi-Gigahertz testing, embedded testing, design for testing room temperature Terahertz circuits and systems, ballistic operation.

Dalila B. Megherbi

Dipl.	Ecole Nationale Polytechnique (ECE)
M.S., ECE	Brown University
M.S. Appl. Math	Brown University
Ph.D.	Brown University

Research Interests: Digital Image Processing, Computer Vision, AI, Networking, Distributed & Embedded System.

Sam Mil'shtein

B.S.	State University of Odessa
M.S.	State University of Odessa
Ph.D.	University of Jerusalem, Israel

Research Interests: Development of novel quantum well and high speed transistors. Design of noise immune amplifiers, low distortion switches, linear mixers. Electronics for bio-engineering and bio-metrics. Infrared imaging for medical.

Siavash Pakadelian

B.S.	Sharif University of Technology, Tehran, Iran
M.S.	University of Tehran, Iran
Ph.D.	Texas A&M University

Research Interests: Magnetic gears and gear-integrated machines, Analysis and design of electric machines, Advanced motion control, Marine and hydrokinetic energy systems, Biomechanical energy harvesting

John Palma

B.S.	Electrical Engineering, Uni. of Rochester
M.S.	Electrical Engineering, University of Mass. Lowell
Ph.D.	Electrical Engineering, University of Mass. Lowell

Research Interest: Semiconductor Device Modeling and Simulation

Kanti Prasad

B.Sc.	Agra University
B.E.	University of Roorkee
Ph.D.	University of South Carolina, PE

Research Interests: Reliability analysis and enhancement for GaAs and silicon devices through novel techniques; Design of protocol controllers for communication systems including wireless; ASIC chip design for communication.

B.S.E. in Electrical Engineering (EE)

The B.S.E. in EE track provides a thorough grounding in the fundamentals of electrical engineering that would allow a graduate to function effectively in industry or continue on to graduate school. A typical curriculum is:

Freshman Year/Fall Semester		**Cr.**	**Freshman Year/Spring Semester**		**Cr.**
EECE 1070	Intro to Eng. I	2	ENGL 1020	College Writing II	3
ENGL 1010	College Writing I	3	MATH 1320	***Calculus II	4
MATH 1310	***Calculus I	4	PHYS 1440	Physics II	3
PHYS 1410	Physics I	3	PHYS 1440L	Physics Lab II	1
PHYS 1410L	Physics Lab I	1	CHEM 1210	Chemistry I	3
			CHEM1230L	Chemistry Lab I	1
		13 CH			15 CH

Sophomore Year/Fall Semester		**Cr.**	**Sophomore Year/Spring Semester**		**Cr.**
EECE.2010	Circuit Theory I **	3	EECE.2020	Circuit Theory II	3
EECE.2070	Basic Circuits Lab I	2	EECE.2080	Basic Circuit Lab II	2
EECE.2160	ECE Applications Programming	3	EECE.2650	Logic Design	3
MATH.2310	Calculus III	4	MATH.2360	Eng. Differential Equations	3
XXXX.XXXX	Arts & Humanities	3	ECON.2010/20	Economics I or II	3
			XXXX.XXXX	Socials Sciences Presp. (SS)	3
		15 CH			17 CH

Junior Year/Fall Semester		**Cr.**	**Junior Year/Spring Semester**		**Cr.**
EECE.3110	Electronics I Lab	2	EECE.3120	Electronics II Lab	2
EECE.3170	Microprocessors Systems Design I		EECE.3600	Eng. Electromagnetics I	3
EECE.3620	Signals & Systems		EECE.3630	Intro to Probability & Random Processes	3
EECE.3640	Eng. Math				
EECE.3650	Electronics I		EECE.366	Electronics II	3
PHIL.3340	Engineering Ethics				
		17 CH			14 CH

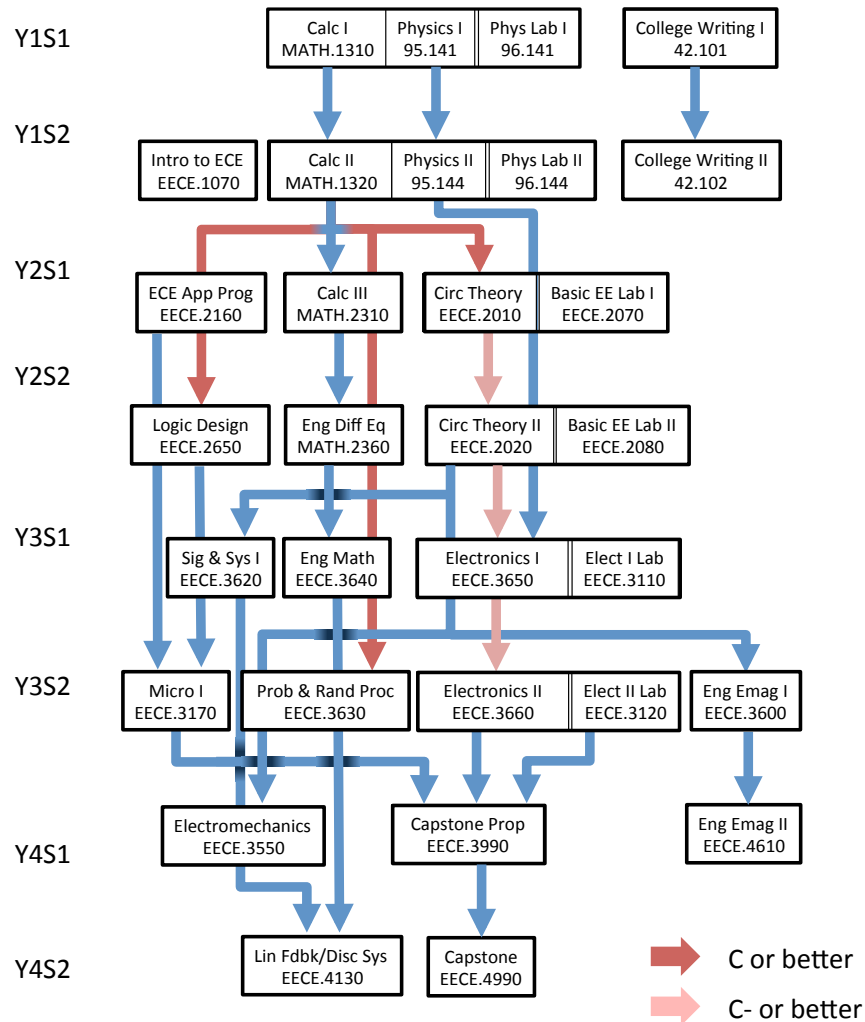| **Senior Year/Fall Semester**		**Cr.**	**Senior Year/Spring Semester**		**Cr.**
EECE.3550	Electromechanics	3	EECE.4130	Linear Feedback Systems	3
EECE.3990	Capstone Prop.	3	EECE.4990	Capstone Project	3
EECE.4610	Eng. Electromagnetics II	3	EECE.XXXX	****Technical Elective	3
EECE.XXXX	****Technical Elective	3	EECE.XXXX	****Technical Elective	3
_____	Arts & Humanities	3	_____	Social Science	3
		15 CH			15 CH

Total Degree Credits = 125
** A grade of C or better in Calculus II is required
***or MATH.1280 Calculus 1A AND MATH.129 Calculus 1B followed by .132 Calculus II
**** Technical electives are non-required courses numbered EECE.4xx or EECE.5xx

The following Flow Chart shows the sequence of courses taken and the prerequisites for each course in the undergraduate BSE in EE curriculum.

Year/
semester

Y1S1

| Calc I MATH.1310 | Physics I 95.141 | Phys Lab I 96.141 | | College Writing I 42.101 |

Y1S2

| Intro to ECE EECE.1070 | Calc II MATH.1320 | Physics II 95.144 | Phys Lab II 96.144 | | College Writing II 42.102 |

Y2S1

| ECE App Prog EECE.2160 | Calc III MATH.2310 | Circ Theory EECE.2010 | Basic EE Lab I EECE.2070 |

Y2S2

| Logic Design EECE.2650 | Eng Diff Eq MATH.2360 | Circ Theory II EECE.2020 | Basic EE Lab II EECE.2080 |

Y3S1

| Sig & Sys I EECE.3620 | Eng Math EECE.3640 | Electronics I EECE.3650 | Elect I Lab EECE.3110 |

Y3S2

| Micro I EECE.3170 | Prob & Rand Proc EECE.3630 | Electronics II EECE.3660 | Elect II Lab EECE.3120 | Eng Emag I EECE.3600 |

Y4S1

| Electromechanics EECE.3550 | Capstone Prop EECE.3990 | Eng Emag II EECE.4610 |

Y4S2

| Lin Fdbk/Disc Sys EECE.4130 | Capstone EECE.4990 |

➡ C or better

➡ C- or better

Tingshu Hu

B.S.   Shanghai Jiao University, China
M.S.   Shanghai Jiao University, China
Ph.D.   University of Virginia

Research Interests: Nonlinear systems theory, control systems with saturation, optimal control and optimization techniques, robust control, control applications to mechanical systems and biomedical systems.

Oliver Ibe

B.Sc.   University of Nigeria
S.M.   Mass. Institute of Technology
M.B.A   Northeastern University
Sc.D.   Mass. Institute of Technology

Research Interests: Mobile and fixed wireless communications, voice over IP networks, communication systems performance analysis, stochastic systems modeling, and statistical systems processing.

Xuejun Lu

B.S.   Peking University
M.S.   University of Texas at Austin
Ph.D.   University of Texas at Austin

Research Interests: Silicon based nanophotonics, uncooled QDIP sensors. Nonlinear thresholding optical gates, guided wave optical interconnects, ultra high-speed transceiver interface, optical CDMA transceivers.

Yan Luo

B.E.   Huazhong University of Science and Technology, China
M.S.   Huazhong University of Science and Technology, China
Ph.D.   University of California Riverside

Research Interests: Network processors, low power processors, internet router and web server architectures, parallel and distributed processing, embedded systems, simulation and performance evaluation.

Mufeed Mah'd
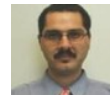
B.S.   Kuwait University
M.S.   University of Jordan
Ph.D.   University of Western Ontario, Canada

Research Interests: Digital signal and medical image processing; nuclear medicine: Positron Emission Tomography (PET), Single Positron Emission Tomography (SPECT); Computerized Tomography (CT); Magnetic Resonance Imagine (MRI). Image reconstruction and restoration; image registration and fusion; real time signal/image code development and hardware implantation.

Department Faculty Profiles

Alkim Akyurtlu

B.S.	Virginia Polytechnic Institute
M.S.	Pennsylvania State University
Ph.D.	Pennsylvania State University

Research Interests: Theoretical and computational electromagnetics with applications to electromagnetic wave interactions with complex materials, antenna theory and design, and microwaves. Modeling of electromagnetic scattering and propagation.

Craig Armiento

B.S.	Electrical Engineering, Manhattan College
S.M.	Electrical Engineering, Mass. Institute of Technology
M.S.	Electrical Engineering, Mass. Institute of Technology
Ph.D.	Electrical Engineering, Mass. Institute of Technology

Research Interests: Fiber optic communication systems; phonic device design, Dense Wavelength Division Multiplexing (DWDM) technologies, optical network design, semiconductor device physics, process development for III-V semiconductors, optical subsystem development using hybrid integration, access network architectures.

Kavitha Chandra

B.E.	Bangladore University
M.S.	University of Massachusetts Lowell
D. Eng.	University of Massachusetts Lowell

Research Interests: Performance analysis of wired and wireless communication networks; network traffic characterization and traffic control, physical layer modeling of wireless channels, computational models for acoustic and electromagnetic wave scattering.

Tricia Chigan

M.S.	Biomedical Engineering, Uni. of Science & Technology of China
M.S.	Electrical Engineering, State University of New York at Stony Brook
Ph.D.	Electrical Engineering, State University of New York at Stony Brook

Cyber Security & Information Assurance; Vehicular Ad Hoc Networks; Cognitive Radio Networks & Security; Wireless Ad Hoc and Sensor Networks; Vehicle-To-Grid (V2G) Communications.

Joyita Datta

B.Tech.	Indian Institute of Technology, Kharagpur, India
M.S.	University of Southern California, Los Angeles, CA
Ph.D	University of Southern California, Los Angeles, CA

Research Interests: Biomedical image reconstruction and analysis

Michael J. Geiger

B.S.	Cornell University
M.S.	University of Michigan
Ph.D.	University of Michigan

Research Interests: High performance computing

B.S.E. in Computer Engineering (CpE)

The B.S.E. in CpE track provides a thorough grounding in the fundamentals of electrical engineering that would allow a graduate to function effectively in industry or continue on to graduate school. A typical curriculum is:

Freshman Year/Fall Semester		Cr.
EECE.1070	Intro to ECE	2
MATH.1310	*Calculus I	4
PHYS.1410	Physics I	3
PHYS.1410L	Physics Lab I	1
ENGL.1010	(Gen. Ed.) College Writing I	3
		13

Freshman Year/Spring Semester		Cr.
MATH.1320	**Calculus II	4
PHYS.1440	Physics II	3
PHYS.1440L	Physics Lab II	1
ENGL.1020	College Writing II	3
CHEM.1210	Chemistry I	3
CHEM.1230L	Chemistry Lab I	1
		15

Sophomore Year/Fall Semester		Cr.
EECE.2010	Circuit Theory I	3
EECE.2070	Basic Circuits Lab I	2
EECE.2650	Logic Design	3
MATH.2310	Calculus III	4
XXXX.XXXX	(Ged. Ed) Elective (A&H)	3
		15

Sophomore Year/Spring Semester		Cr.
EECE.2020	Circuit Theory II	3
EECE.2080	Basic Circuit Lab II	2
EECE.2160	ECE Applications Programming	3
MATH.2360	Eng. Differential Equations	3
MATH.3600	Math Structures for CpE	3
ECON.2010/2020 Economics I or II (Gen. Ed. SS)		3
		17

Junior Year/Fall Semester		Cr.
EECE.3110	Electronics I Lab	2
EECE.3220	Data Structures & Algorithms	3
EECE.3620	Signals & Systems	3
EECE.3640	Eng. Math	3
EECE.3650	Electronics I	3
xxxx.xxxx	(Gen. Ed.) Elective (SS)	3
		17

Junior Year/Spring Semester		Cr.
EECE.3120	Electronics II Lab	2
EECE.3170	Microprocessors I	3
xxxx.xxxx	(Gen. Ed.) Elective (AH)	3
EECE.3630	Intro to Prob. & Random Proc.	3
EECE.3660	Electronics II	3
PHIL.3340	(Gen. Ed.) Eng. Ethics (AH)	3
		17

Senior Year/Fall Semester		Cr.
EECE.3990	Capstone Proposal	3
EECE.4500	Adv. Digital System Design	3
EECE.4800	Microprocessors II	3
EECE.4810	Operating System	3
EECE.4/5xxx	Technical Electives***	3
		15

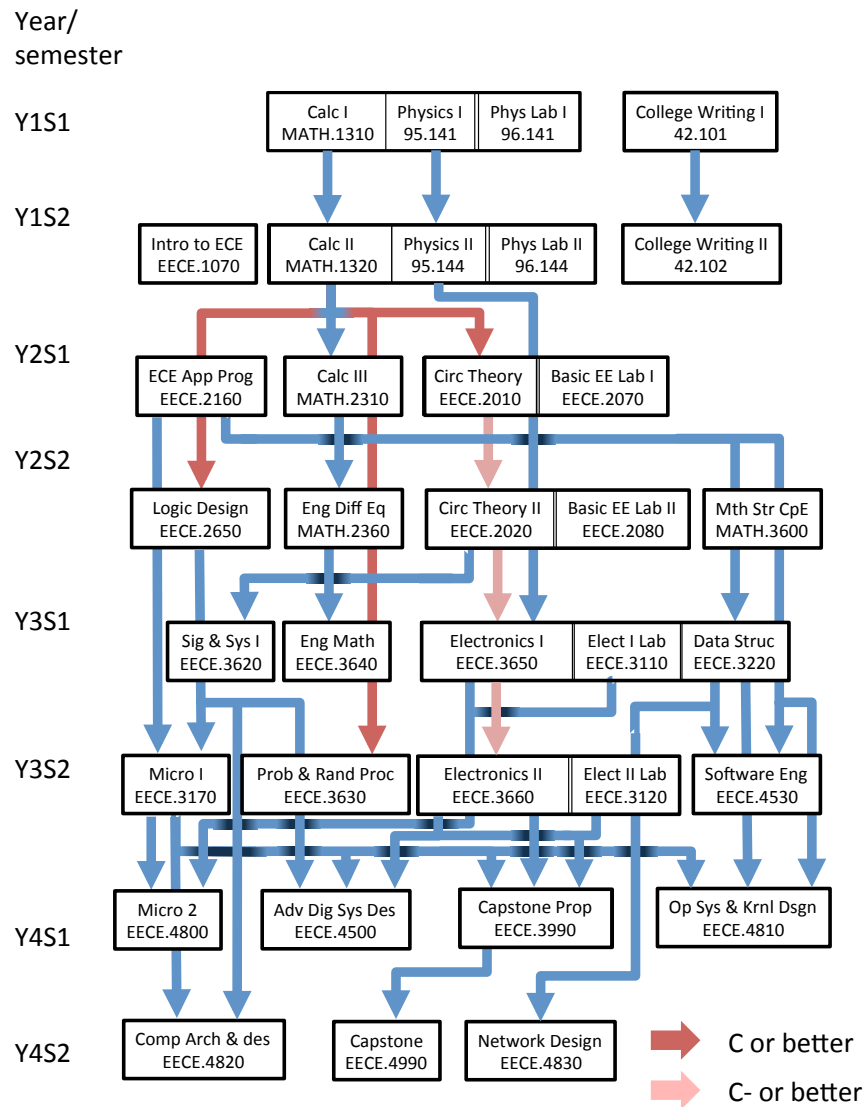| Senior Year/Spring Semester		Cr.
EECE.4820	Computer Architecture	3
EECE.4830	Network Design	3
EECE.4990	Capstone Project	3
EECE.4/5xxx	Technical Elective***	3
xxxx.xxxx	(Gen. Ed.) Elective (SS)	3
		15

Total Degree = 124 CH

The General Education (Gen. Ed.) Electives for SS and AH may be taken in any order. Consult the General Education website for the list of approved courses. A student can only take two General Education courses from the same department.

*Or MATH.1280 (Calculus 1A) and MATH.1290 (Calculus 1B) followed by MATH.1320 (Calculus II)
** A grade of C or better in Calculus II is required.
*** Technical Electives are non-required courses numbered EECE.4xxx or EECE.5xxx.

The following Flow Chart shows the sequence of courses taken and the prerequisites for each course in the undergraduate BSE Eng in CpE curriculum.

Year/semester

Y1S1

| Calc I MATH.1310 | Physics I 95.141 | Phys Lab I 96.141 | College Writing I 42.101 |

Y1S2

| Intro to ECE EECE.1070 | Calc II MATH.1320 | Physics II 95.144 | Phys Lab II 96.144 | College Writing II 42.102 |

Y2S1

| ECE App Prog EECE.2160 | Calc III MATH.2310 | Circ Theory EECE.2010 | Basic EE Lab I EECE.2070 |

Y2S2

| Logic Design EECE.2650 | Eng Diff Eq MATH.2360 | Circ Theory II EECE.2020 | Basic EE Lab II EECE.2080 | Mth Str CpE MATH.3600 |

Y3S1

| Sig & Sys I EECE.3620 | Eng Math EECE.3640 | Electronics I EECE.3650 | Elect I Lab EECE.3110 | Data Struc EECE.3220 |

Y3S2

| Micro I EECE.3170 | Prob & Rand Proc EECE.3630 | Electronics II EECE.3660 | Elect II Lab EECE.3120 | Software Eng EECE.4530 |

Y4S1

| Micro 2 EECE.4800 | Adv Dig Sys Des EECE.4500 | Capstone Prop EECE.3990 | Op Sys & Krnl Dsgn EECE.4810 |

Y4S2

| Comp Arch & des EECE.4820 | Capstone EECE.4990 | Network Design EECE.4830 |

➤ C or better
➤ C- or better

EECE.7430 Master's Thesis in Electrical and Computer Engineering 3 credits

EECE.7460 Master's Thesis in Electrical and Computer Engineering 6 credits

EECE.7490 Master's Thesis in Electrical and Computer Engineering 9 credits

Requirement for EECE.7430, EECE.7460, and EECE.7490
A student cannot register for more than a total of three credits in his/her Masters degree program before completing two 3.0-credit Electrical and Computer Engineering graduate courses. Prerequisite: Permission of Instructor thesis advisor and filing of a thesis agreement signed by the student and the instructor thesis advisor with the Electrical and Computer Engineering Department office.

EECE.7510 Doctoral Dissertation in Electrical and Computer Engineering 1 credit

EECE.7530 Doctoral Dissertation in Electrical and Computer Engineering 3 credits

EECE.7540 Doctoral Dissertation in Electrical and Computer Engineering 4 credits

EECE.7550 Doctoral Dissertation in Electrical and Computer Engineering 5 credits

EECE.7560 Doctoral Dissertation in Electrical and Computer Engineering 6 credits

EECE.7570 Doctoral Dissertation in Electrical and Computer Engineering 7 credits

EECE.7590 Doctoral Dissertation in Electrical and Computer Engineering 9 credits

Requirement for EECE.7510, EECE.7530, EECE.7540, EECE.7550, EECE.7560, EECE.7570, and EECE.7590
Written approval by the dissertation advisor; matriculated status in the doctoral program in EE. No more than 9 credits of doctoral dissertation research may be taken before passing the doctoral qualifying examination. No more than 15 credits of doctoral dissertation research may be taken before passing the defense of the thesis proposal examination. Prerequisite: Permission of Instructor dissertation advisor and filing of a dissertation agreement signed by the student and the instructor dissertation advisor with the Electrical and Computer Engineering Department office.

EECE.7630 Continued Graduate Research 3 credits

EECE.7660 Continued Graduate Research 6 credits

EECE.7690 Continued Graduate Research 9 credits

Requirement for EECE.7630, EECE.7660, and EECE.7690
Students who do not meet the requirement of EECE.7430, EECE.7460, EECE.7490, EECE.7510, EECE.7530, EECE.7540, EECE.7550, EECE.7560, EECE.7570, and EECE.7590 for theses or dissertations may register for EECE.7630, EECE.7660, and EECE.7690. The credits cannot count toward their degree programs. Prerequisite: Permission of thesis/dissertation advisor
.

EECE.6690 Opto Electronic Devices
Topics of this class include: Semiconductor energy bands, PN junction principles, LED principles and device structures, Heterojunctions, Semiconductor Lasers, Quantum wells, Vertical cavity surface emitting lasers (VCSEL), PIN Photodiode, Avalanche Photodiode, Electro-absorption modulators. Prerequisite: EECE.3600, EECE.4740 or EECE.5760 or EECE.5950.

EECE.6880 Theoretical Acoustics
Fundamental equations: elasticity and fluid equations. Linear Acoustics: equations of fluid at rest, transmission, reflection and propagation of planar waves, radiation of sound, scattering and diffraction of sound, acoustic waveguides and rooms. Acoustics in inhomogeneous media: sheared mean flow, varying sound speed. Nonlinear Acoustics: shock waves, nonlinear viscous effects. Prerequisite: Permission of Instructor.

EECE.6920 Directed Studies
Provides an opportunity to get a specialized or customized instruction in consultation with a faculty member. This course is not intended as a vehicle for research projects. It may only be taken in the last semester of a student's Masters program. This course is intended only for Masters students and can only be taken once. Documentation is required and must be approved by the ECE Graduate Coordinator (who will provide a permission number). The documentation must include the course syllabus, frequency and time/date of meetings, grading policy, and expectations of the instructor.

EECE.7100 Selected Topics I in Electrical and Computer Engineering
Advanced topics in various areas of Electrical and Computer Engineering and related fields. Prerequisite: Specified at time of offering.

EECE.7110 Selected Topics II in Electrical and Computer Engineering
Advanced topics in various areas of Electrical and Computer Engineering and related fields. Prerequisite: Specified at time of offering.

EECE.7250 Selected Topics III in Electrical and Computer Engineering
Advanced topics in various areas of Electrical and Computer Engineering and related fields. Prerequisite: Specified at time of offering.

EECE.7290 Selected Topics IV in Electrical and Computer Engineering
Advanced topics in various areas of Electrical and Computer Engineering and related fields. Prerequisite: Specified at time of offering.

EECE.7330 Advanced Graduate Project
The Advanced Project is a substantial investigation of a research topic under the supervision of a faculty member. A written report is required upon completion of the project. However, this course is graded only on a Pass or Fail basis and hence will not factor in the CGPA. It can be taken only once and the credits can be applied only to the requirements of the non-thesis option. The Advanced Project may evolve into a master's thesis and be converted to EECE.7430 by filing a petition before the final grade is submitted to the Registrar at the end of the semester. Prerequisite: Permission of Instructor and filing of a graduate project agreement signed by the student and the instructor with the Electrical and Computer Engineering Department office.

Double Major: Undergraduate EE/CS Curriculum

The ECE Department also offers a double major in Electrical Engineering/Computer Science Students must adhere to the University and college policy on double majors. All curriculum requirements in Engineering must be satisfied. The student must inform both Departments/Colleges by the start of the junior year; the student must submit a program for approval by the Departments involved; the Dean must approve declaration of a double major; a declaration of second major form must be submitted to the Office of Enrollment; students may not present less than 57 credits outside the two major fields in order to satisfy the minimum degree requirements of 120; students are awarded their degree in one college (they must choose)

Freshman Year/Fall Semester		Cr.	Freshman Year/Spring Semester		Cr.
EECE 1070	Intro to Eng. I	2	ENGL 1020	College Writing II	3
ENGL 1010	College Writing I	3	MATH 1320	***Calculus II	4
MATH 1310	***Calculus I	4	PHYS 1440	Physics II	3
PHYS 1410	Physics I	3	PHYS 1440L	Physics Lab II	1
PHYS 1410L	Physics Lab I	1	CHEM 1210	Chemistry I	3
			CHEM1230L	Chemistry Lab I	1
		14 CH			17 CH

Sophomore Year/Fall Semester		Cr.	Sophomore Year/Spring Semester		Cr.
EECE.2010	Circuit Theory I **	3	EECE.2020	Circuit Theory II	3
EECE.2070	Basic Circuits Lab I	2	EECE.2080	Basic Circuit Lab II	2
EECE.2160	ECE Applications Programming	3	EECE.2650	Logic Design	3
MATH.2310	Calculus III	4	MATH.2360	Eng. Differential Equations	3
XXXX.XXXX	Arts & Humanities	3	ECON.2010/20	Economics I or II	3
			XXXX.XXXX	Socials Sciences Presp. (SS)	3
		15 CH			17 CH

Junior Year/Fall Semester		Cr.	Junior Year/Spring Semester		Cr.
EECE.3110	Electronics I Lab	2	EECE.3120	Electronics II Lab	2
EECE.3170	Microprocessors Systems Design I		EECE.3600	Eng. Electromagnetics I	3
EECE.3620	Signals & Systems		EECE.3630	Intro to Probability & Random Processes	3
EECE.3640	Eng. Math				
EECE.3650	Electronics I		EECE.3660	Electronics II	3
PHIL.3340	Engineering Ethics				
		17 CH			14 CH

Senior Year/Fall Semester		Cr.	Senior Year/Spring Semester		Cr.
EECE.3550	Electromechanics	3	EECE.4130	Linear Feedback Systems	3
EECE.3990	Capstone Prop.	3	EECE.4990	Capstone Project	3
EECE.4610	Eng. Electromagnetics II	3	EECE.XXXX	****Technical Elective	3
EECE.XXXX	****Technical Elective	3	EECE.XXXX	****Technical Elective	3
_____	Arts & Humanities	3	_____	Social Science	3
		15 CH			15 CH

Total Degree = 138 CH
** A grade of C or better in Calculus II is required ***or EECE.1280 Calculus 1A AND EECE.1290 Calculus 1B followed by EECE.1320 Calculus II

Double Major: Undergraduate EE/Physics Curriculum

The ECE Department also offers a double major in Electrical Engineering/Physics. Students must adhere to the University and college policy on double majors. All curriculum requirements in Engineering must be satisfied. The student must inform both Departments/Colleges by the start of the junior year; the student must submit a program for approval by the Departments involved; the Dean must approve declaration of a double major; a declaration of second major form must be submitted to the Office of Enrollment; students may not present less than 57 credits outside the two major fields in order to satisfy the minimum degree requirements of 120; students are awarded their degree in one college (they must choose one; otherwise, the degree will come from the college originally enrolled in).

Freshman Year/Fall Semester		Cr.	Freshman Year/Spring Semester		Cr.
EECE.1070	Intro to ECE	2	MATH.1320	Calculus II***	4
MATH.1310	Calculus I***	4	PHYS 1440	Physics II	3
PHYS 1410	Physics I	3	PHYS 1440L	Physics Lab II	1
PHYS 1410L	Physics Lab I	1	ENGL.1020	College Writing II	3
CHEM.1210	Chemistry I	3	PHYS.1120	Freshman Physics Seminar	1
CHEM.1230L	Chemistry I Lab	1	CHEM.1210	Chemistry II	3
ENGL.1010	College Writing I	3	CHEM.1230L	Chemistry II Lab	1
		17 CH			16 CH

Sophomore Year/Fall Semester		Cr.	Sophomore Year/Spring Semester		Cr.
EECE.2010	Circuit Theory I **	3	EECE.2020	Circuit Theory II	3
EECE.2070	Basic EE Lab I	2	EECE.2080	Basic EE Lab II	2
PHYS.2450	Physics III (H)	4	MATH.2360	Eng. Differential Equations	3
MATH.2310	Calculus III	4	EECE.2650	Logic Design	3
PHYS.2610L	Physics Mat & Dev	3	PHYS.2100	Intro to Modern Physics	3
			PHYS.2620L	Princ Lab Auto	3
		16 CH			17 CH

Junior Year/Fall Semester		Cr.	Junior Year/Spring Semester		Cr.
EECE.3110	Electronics I Lab	2	EECE.3120	Electronics II Lab	2
ECON.2010 or ECON.2020	Economics I or Economics II	3	EECE.3170	Microprocessors Systems Des I	3
EECE.3620	Signals & Systems I	3	PHYS.3820	Math Physics II	3
PHYS.3810	Math Physics I	3	EECE.3630	Intro to Prob. & Random	3
EECE.3650	Electronics I	3	PHYS.4350	Proc. *	3
PHYS.3930L	Adv. Exper Physics I	2		Intro Quant Mech I	
			PHYS.3940L	Adv. Exp. Physics Lab II	2
		16 CH			19 CH

Senior Year/Fall Semester		Cr.	Senior Year/Spring Semester		Cr.
EECE.3600 or PHYS.3530	Electromechanics or Electromagnetism I	3	EECE.4990	International Finance	3
EECE.3990	Capstone Prop.	3	xxxx.xxxx	General Education (SS)	3
PHIL.3340	Eng. & Ethics (AH)	3	xxxx.xxxx	General Education (SS)	3
PHYS.4210	Start Therm	3	xxxx.xxxx	General Education (AH)	3
PHYS.4130	Mechanics	3	xxxx.xxxx	Strategic Management	3
		15 CH			15 CH

Total Degree = 131 CH

* Formerly Signals & Systems II.
** A grade of C or better in Calculus.
*** Or MATH.1280 Calculus 1A and MATH.1290 Calculus 1B followed by MATH.1320 Calculus II.

EECE.6560 Fault Tolerant Systems Design*
Covers the design and analysis of Fault-Tolerant Systems (hardware and software levels). Redundancy techniques are used for the creation of hardware redundancy, and information redundancy. Topics include: hardware and software architecture of fault-tolerant computers, fault tolerance through dynamic or stand-by redundancy, fault detection in multiprocessors, fault detection through duplication and comparison, fault detection using diagnostics and coding techniques, recovery strategies for multiprocessor systems, rollback recovery using hardware checkpoints and control digital logic for processor-cache-based checkpoints. Prerequisite: EECE.5610 or EECE.6500.

EECE.6580 Network Security
This course will cover two categories of topics: One part is the fundamental principles of cryptography and its applications to network and communication security in general. This part focuses on cryptography algorithms and the fundamental network security enabling mechanisms. Topics include attack analysis and classifications, public key cryptography (RSA, Diffie–Hellman), Secret key cryptography (DES, IDEA), Hash (MD5, SHA-1) algorithms; Key distribution and management; Security handshake pitfalls and authentications; and well known network security protocols such as Kerberos, IPSec, SSL/SET, PGP & PKI, WEP. The second part covers the advanced topics on the security issues of MANET (including VANET), WSN, Smart Grid, Cognitive Radio Network, and Cloud Computing. This part involves diverse literature review on the unique security challenges and open issues faced by these emerging network technologies, and the state-of-the-art security solutions in literature. Prerequisite: Permission of Instructor.

EECE.6590 Distributed Systems*
Covers principles of distributed systems, fundamentals of distributed computing models. The concepts of distributed file and directory services, distributed systems hardware and software design are studied. Topics include implementation of DS issues, reliability and availability, and fault tolerance. System bus structure for distributed systems, and design and implementation of the hardware distributed shared memory are studied. It also addresses logical synchronization and clock synchronization, resource allocation, self-stabilization of network protocols, graph partitions. Laboratories includes implementation of distributed systems (hardware and software) PVM, MPI and JINI. Prerequisites: EECE.2160 or Programming Skills and EECE.5830 or EECE.7130.

EECE.6600 Mobile Communication Networks
Covers the fundamentals of mobile data communications. Introduces state-of-the-art mobile network architectures (Hardware and Software). Addresses an overview of wireless networks. Topics include architecture of existing mobile data networks: ARDIS, Mobitex, TETHRA, Merticom, CDPD and GPRS, wireless LAN technologies: 802.11, HIPERLAN, and wireless ATM. Studies the effects of mobility on different ISO layers, physical layer options, MAC layer in mobile environment, issues in mobile computing, mobile IP and DHCP. It also addresses mobility gateway technologies: MASE and eNetwork, inter-tech roaming and handover for wireless data networks. Laboratories include software tools for simulation of hardware Mobile networks. Prerequisite: EECE.5830.

EECE 6660 - Storage Area Networks
A storage area network (SAN) is a separate network of storage devices physically removed from, but still connected to, the network. SANs evolved from the concept of taking storage devices, and therefore storage traffic, off the LAN and creating a separate back-end network designed advantages and disadvantages. Prerequisite: Permission of instructor.

EECE.5950 Solid-State Electronics
Topics included are physical limits of microminiaturization, metal semiconductor junctions, p-n junctions diodes, (rectifiers, varactors, tunnel diodes and photodetectors and solar cells); bipolar junction transistors, field effect transistors (junction FET, MESFET, MOSFET); heterojunction devices and high speed devices; quantum dots, wires and two dimensional quantum well devices, light emitting devices; flat panels, liquid crystals and hot electron emitters. Prerequisite: EECE.5230.

EECE.6120 Converged Voice and Data Network
Covers the technologies and protocols used to transport voice and data traffic over a common communication network, with emphasis on voice over IP (VoIP). The specific topics covered include voice communication network fundamentals, data networking fundamentals, voice packet processing, voice over packet networking, ITU-T VoIP architecture, IETF VoIP architecture, VoIP over WLAN,m access networks for converged services: DSL and HFC networks, and IP TV service. Prerequisite: EECE.5460 or Permission of Instructor.

EECE.6160 Computational Power System Analysis*
Power system matrices, power flow studies, fault studies, state estimation, optimal power dispatch, and stability studies. Prerequisites: EECE.4430 and EECE.5200.

EECE.6170 Modeling and Simulation Techniques for Communication Networks
Overview of general architectures for broadband networks. Performance requirements, traffic management strategies, usage parameter control, connection admission control and congestion control. Stochastic processes models for voice, video and data traffic: Poisson processes, Markov chains and Markov-modulated processes; Queuing analysis: M/M/1, M/M/m, M/G/1 queues, fluid buffer models, effective bandwidth approaches; Simulation and computational modeling: discrete event simulation of transport and multiplexing protocols, statistical techniques for validation and sensitivity analysis. Prerequisite: EECE.5840 and Basic Programming Skills or Permission of Instructor.

EECE.6500 Advanced Computing Systems Hardware Architecture
Covers the latest advanced techniques in CPU design, floating point unit design, vector processors, branch prediction, shared memory versus networks, scalable shared memory systems, Asynchronous shared memory algorithms, systems performance issues, advanced prototype hardware structures, and future trends including TeraDash systems. Prerequisite: EECE.5610.

EECE.6520 Parallel and Multiprocessor Architectures*
Study of principles of parallel processing and the design of hardware and software parallel computer architectures for a variety of models, including SIMD, MIMD. It also presents the issues related to designing and programming tightly-coupled shared-memory multiprocessor systems at the hardware level. Issues of memory structure, snoopy and directory-based caching, embedded memory consistency, cache controller coherency, processor interconnect strategies, and multiprocessor scalability, synchronization primitives, task scheduling, and memory allocation are covered. Prerequisites: EECE.4800 or EECE.5520 and EECE.5610.

EECE.6530 Artificial Intelligence and Machine Learning*
Study of automated reasoning; representing change and the effects of actions; problem solving and planning. Includes the development of working programs that search, reason, and plan intelligently. Controlling physical mobile robot systems that operate in dynamic, unpredictable environments is covered. Building smart embedded chips for machine learning. Also covers neural networks, Fuzzy logic, genetic Algorithms and other approaches to machine learning. Prerequisites: EECE.2160 or Programming Skills and EECE.3220.

Combined BSE/MSE Engineering Program

The combined BSE/MSE program is an accelerated program offered by the Department of Electrical and Computer Engineering to encourage its outstanding undergraduate students to continue study at the graduate level. Undergraduate students who have a GPA of 3.00 or better at the end of their junior year and are interested in this program must apply for this program before they complete the undergraduate graduation requirements. Students who apply for the BSE/ MSE program are not required to submit the Graduate Record Examination (GRE) scores and are exempted from the application fee

A principal benefit of the early identification of academic goals by the student and advisor is a careful structuring of course work that permits the scheduling of prerequisites and required courses in sequence, thus affecting a considerable savings of time.

Graduate Programs

The Department of Electrical and Computer Engineering graduate program provides an education based on excellent teaching and cutting-edge research to qualify students as leaders in both industrial and academic environments. It is distinguished by an extensive set of courses in all of the major disciplines within electrical and computer engineering fields. Our mission is supported by six research centers, over ten research laboratories and a world-class faculty with ongoing research in a broad set of disciplines. The program offers masters degrees in both Electrical Engineering and Computer Engineering, as well as two doctoral degrees, Doctor of Philosophy and Doctor of Engineering, in Electrical Engineering and Computer Engineering.

The Department of Electrical and Computer Engineering awards the following graduate degrees:
- Masters of Science in Electrical Engineering
- Masters of Science in Computer Engineering
- Doctor of Philosophy in Electrical Engineering
- Doctor of Philosophy in Computer Engineering
- Doctor of Engineering in Electrical Engineering
- Doctor of Engineering in Computer Engineering

Research is conducted and courses offered in the following areas:
- Artificial/Machine Intelligence
- Bio-Engineering/Bio-Informatics/Bio-Sensors
- Computational Engineering
- Computing and Embedded Systems Hardware and Architecture
- Electric Vehicles and Battery Technology
- Electromagnetics
- Ionospheric Measurements
- Microwave Engineering
- Optoelectronic and Semiconductor Devices
- Power Systems
- Quantum/Nano Electronics
- Signal/Image Processing and Computer Vision
- Solar Energy and Photovoltaics
- Stochastic Processes
- VLSI Design and Fabrication

Four graduate certificates in Electrical and Computer Engineering and six interdisciplinary certificates in corporation with other departments are also offered. These certificates allow students who are not in a degree program to further their education. Approvals to take courses associated with these certificates are subject to approval of the certificate coordinator. Because there is no transfer policy for certificates, students should not take any course for certificates before being accepted.

Electrical and Computer Engineering
- Communications Engineering
- Field Programmable Gate Array
- Microwave and Wireless Engineering
- VLSI and microelectronics

Interdisciplinary
- Biomedical Engineering
- Energy Conversion
- Integrated Engineering Systems
- Nanotechnology
- Photonics and Optoelectronics
- Telecommunications

Master of Science in Engineering (MSE) Programs

The ECE Department offers two Masters programs:
MS Eng. Program in Electrical Engineering (EE)
MS Eng. Program in Computer Engineering (CP)

Graduate Admissions Requirements

General requirement for all applications

All applicants must submit the application materials supplied by the Graduate School as well as the official score report for the Graduate Record Examination (GRE) Aptitude Test.

Students with a BS in Engineering and related areas

Applicants to the MS Engineering in EE or CP programs should hold a BS degree in EE, CP, areas related to EE or CP, Computer Science, Mathematics, Physics, or other Engineering disciplines, with acceptable quality of undergraduate work from an accredited college or university.

Applicants to the MS Engineering in EE or CP should possess the following backgrounds and their prerequisites.

Electrical Engineering
- EECE.2160   A high-level programming language such as C/C++
- EECE.2650   Logic Design
- EECE.3110   Electronics Lab I
- EECE.3170   Microprocessor Systems Design I
- EECE.3600   Engineering Electromagnetics I
- EECE.3620   Signal and Systems
- EECE.3650   Electronics I
- EECE.4130   Linear Feedback Systems

EECE.5810 Computer Vision and Digital Image Processing
Introduces the principles and the fundamental techniques for Image Processing and Computer Vision. Topics include programming aspects of vision, image formation and representation, multi-scale analysis, boundary detection, texture analysis, shape from shading, object modeling, stereo-vision, motion and optical flow, shape description and objects recognition (classification), and hardware design of video cards. AI techniques for Computer Vision are also covered. Laboratories include real applications from industry and the latest research areas. Prerequisites: EECE.2160 or EECE.3220, EECE.3620 or Permission of Instructor.

EECE.5820 Wireless Communications
Cellular systems and design principles, co-channel and adjacent channel interference, mobile radio propagation and determination of large scale path loss, propagation mechanisms like reflection, diffraction and scattering, outdoor propagation models, Okumura and Hata models, small scale fading and multipath, Doppler shift and effects, statistical models for multipath, digital modulation techniques QPSK, DPSK, GMSK, multiple access techniques, TDMA, FDMA, CDMA, spread spectrum techniques, frequency hopped systems, wireless systems and worldwide standards. Prerequisite: EECE.3600.

EECE.5830 Network Design: Principles, Protocols and Applications
Covers design and implementation of network software that transforms raw hardware into a richly functional communication system. Real networks (such as the Internet, ATM, Ethernet, Token Ring) will be used as examples. Presents the different harmonizing functions needed for the interconnection of many heterogeneous computer networks. Internet protocols, such as UDP, TCP, IP, ARP, BGP and IGMP, are used as examples to demonstrate how internetworking is realized. Applications such as electronic mail and the WWW are studied. Topics include: inter-network architectures, high speed network service proto- col implementation, addressing and address mapping, intra- and inter-domain routing, multicasting, mobility, auto-configuration, resource allocation, transport protocols, naming, client-server model, network programming interfaces (e.g., sockets, RMI, RPC, CORBA), secure transport protocols for high-speed networks and applications. Prerequisite: EECE.2160 or Programming Skills.

EECE.5840 Probability and Random Processes
Sample space, Field and Probability Measure. Axiomatic definition of Probability. Bayes' theorem. Repeated trials. Continuous and discrete random variables and their probability distribution and density functions. Functions of random variables and their distribution and density functions. Expectation, variance and higher order moments. Characteristic and generating functions. Vector formulation of random variables and their parameters. Mean square estimation and orthogonality principle. Criteria for estimators. Introduction to random processes: distribution and density functions; Ensemble and time averages; correlation functions and spectral densities. Classification of random processes. Random processes through linear systems. Weiner filters and Kalman filters. Simulation of random variables and hypothesis tests. Prerequisite: EECE.3620.

EECE.5900 Fiber Optic Communications
Optical fiber; waveguide modes, multimode vs. single mode; bandwidth and data rates; fiber losses; splices, couplers, connectors, taps and gratings; optical transmitters; optical receivers; high speed optoelectronic devices; optical link design; broadband switching; single wavelength systems; wavelength division multiplexing; fiber amplifiers. Prerequisites: EECE.3600 and EECE.3620 or Permission of Instructor.

EECE.5930 Industrial Experience
This no credit course is for co-op or industrial experience.

EECE.5710 Radar Systems
Introduction to both pulsed and C. W. radar systems. The radar equation and its use in estimating performance of a radar system. Estimation of range, direction and velocity of targets. Detection of radar echoes in noise. Range and Doppler resolution. Basics of Tracking systems. A final project is required in the course. Prerequisites: EECE.3620, EECE.3630, and EECE.4610 or Permission of Instructor.

EECE.5720 Embedded Real-Time Systems
Design of embedded real-time computer systems. Polled vs. interrupt-driven input/output. Writing interrupt handlers. Types of real-time systems, including foreground/ background, non-preemptive multitasking, and priority-based preemptive multitasking systems. Soft vs. hard real-time systems. Task scheduling algorithms and deterministic behavior. Task synchronization and inter-task communication including: semaphores, mutexes, mailboxes, and message queues. Deterministic memory management schemes. Application and design of a real-time kernel. A project is required. Prerequisites: EECE.2160, EECE.3170, and EECE.3220 or Permission of Instructor.

EECE.5730 Operating Systems and Kernel Design
Covers the components, design, implementation, and internal operations of computer operating systems. Topics include basic structure of operating systems, Kernel, user interface, I/O device management, device drivers, process environment, concurrent processes and synchronization, inter- process communication, process scheduling, memory management, deadlock management and resolution, and file system structures. laboratories include examples of components design of a real operating systems. Prerequisite: EECE.2160 or Programming Skills.

EECE.5740 Advanced Logic Design
Error detection and correction codes. Minimization of switching functions by Quine-McCluskey (tabular) methods. Minimization of multiple-output circuits. Reed-Muller polynomials and exclusive-OR circuits. Transient analysis of hazards. Hazard-free design. Special properties of switching algebra. Programmable logic devices. Analysis and synthesis of fundamental-mode and pulsed-mode sequential circuits. Test sets and design for testability. Prerequisite: EECE.2650.

EECE.5750 Field Programmable Gate Array Logic Design Techniques
This course presents advanced logic design techniques using FPGA's, PLD's, PAL's, and other forms of reconfigurable logic. Architectural descriptions and design flow using Verilog and VHDL will be covered as well as rapid prototyping techniques, ASIC conversions, in-system programmability, and case studies highlighting the tradeoffs involved in designing digital systems with programmable devices. Prerequisite: EECE.2650 or Equivalent.

EECE.5760 Principles of Solid-State Devices
Introduces the principles of Solid State Devices. Crystal properties and growth of semiconductors, atoms and electrons, Bohr's model, quantum mechanics, bonding forces and energy bands in solids, charge carriers in semiconductors, drift of carriers in electric and magnetic fields, carrier lifetime and photoconductivity, junctions, forward and reverse bias, reverse bias breakdown (Zener effect), tunnel diodes, photodiodes, LED, bipolar junction transistors, field effect transistors. A design project is included in the course. Prerequisite: EECE.3650.

EECE.5770 Verification of Very Large Digital Designs
The increasing complexity of digital designs coupled with the requirement for first pass success creates a need for an engineered approach to verification. This course defines the goals for verification, presents techniques and applications, and develops a framework for managing the verification process from concept to reality. Prerequisite: EECE.5740 or Equivalent.

Computer Engineering

EECE.2160	A high-level programming language such as C/C++
EECE.2650	Logic Design
EECE.3110	Electronics Lab I
EECE.3170	Microprocessor Systems Design I
EECE.3620	Signal and Systems
EECE.3640	Engineering Mathematics (or another appropriate advanced course beyond MATH.2310 Calculus III and MATH.2360 Engineering Differential Equations)
EECE.3650	Electronics I

Applicants who lack any of the above backgrounds and their prerequisites are required to make up their deficiencies as conditions for acceptance.

Students with a BS in Technology

Students who lack the BS Engineering in EE or CP but hold a bachelor's degree in Electrical or Computer Engineering Technology, or Electronics Technology may be admitted under special circumstances. These circumstances include an academic record of high achievement in their undergraduate studies in Technology as evaluated at the discretion of the Graduate Coordinator.

In addition, such students must complete a series of analytically oriented courses in the Department of Electrical and Computer Engineering, University of Massachusetts Lowell.

Students applying for the combined BS/MS program

The combined BS/MS program is an accelerated program offered by the Department of Electrical and Computer Engineering to encourage its outstanding undergraduate students to continue study at graduate level. Undergraduate students who have a GPA of 3.00 or better at the end of their junior year and are interested in this program must apply for this program before they complete the undergraduate graduation requirements. Students who apply for the BS/MS program are not required to submit the Graduate Record Examination (GRE) scores and are exempted from the application fee.

Academic Advisor

The ECE Graduate Coordinator will be the academic advisor to all graduate students admitted to Department. The coordinator will assist in the selection of courses and will work with the student to help meet the degree requirements. In cases where the graduate student pursues a thesis-based program, the students' thesis advisor can also provide guidance on course selection. The Graduate Coordinator is responsible for insuring that Masters students have fulfilled all program requirements prior to graduation. Similarly, the ECE Doctoral Coordinator will coordinate the degree requirements for doctoral students.

Academic Requirements

Graduate students can choose to complete a thesis or a non-thesis option. Students are required to take 9 credits of core courses as well as elective courses to complete their program of study.

1. **Credit Requirements**

Non-Thesis Option		Thesis Option	
Core Requirements	9	Core Requirements	9
Technical Electives	21	Technical Electives	15
Advanced Project	3	Thesis	6
		*EECE.6010 or EECE.6020 Graduate Seminar	0

Total credit hours..............33 credits   Total credit hours..........................30 credits
* Graduate Seminar not required for students admitted before Fall 2013.

Students in the combined BS/MS program may use up to six credits of graduate courses for both graduate and undergraduate degrees.

Technical electives are Electrical and Computer Engineering graduate course and concentration courses. Students may choose their technical electives in their area of concentration and across other areas to establish a broad knowledge base. Graduate courses in Computer Science, Mathematics, Physics, and other engineering disciplines may be taken as technical electives only if they are pre-approved by the Graduate Coordinator for non-thesis option, or concurrently by the Graduate Coordinator and the student's thesis advisor for thesis option.

The Advanced Graduate Project can be replaced with a 3-credit technical elective.

2. **Core Requirements**

The objective of the core requirement is to guarantee broad analytical strength for the MS Engineering students.

Required Core Courses for MS in Electrical Engineering
- EECE.5070   Electromagnetic Waves and Materials
- EECE.5080   Quantum Electronics for Engineers
- EECE.5090   Linear Systems Analysis
- EECE.5130   Control Systems
- EECE.5150   Power Electronics
- EECE.5200   Computer-Aided Engineering Analysis
- EECE.5430   Theory of Communications
- EECE.5840   Probability and Random Processes
- EECE.5950   Solid State Electronics

Students in Electrical Engineering must take three of the above courses that may be pertinent to their area of concentration.

Required Core Courses for MS in Computer Engineering
- EECE.5530   Software Engineering
- EECE.5610   Computer Architecture and Design
- EECE.5620   VHDL/Verilog Synthesis and Design
- EECE.5730   Operating Systems and Kernel Design
- EECE.5740   Advanced Logic Design

Students in Computer Engineering must take three of the above courses that may be pertinent to their area of concentration.

EECE.5560 Robotics
Introduces the basic aspects of mobile robotics programming, starting at low-level PID control and behavioral robot control. Covers the analysis, design, modeling and application of robotic manipulators. Forward and inverse kinematics and dynamics, motion and trajectory control and planning are also covered. Laboratories include design, analysis and simulation of real life industrial robots. Prerequisite: Permission of Instructor.

EECE.5590 Introduction to Nanoelectronics
This course introduces the use of nanomaterials for electronic devices such as sensors and transistors. Synthesis methods for nanoparticles, nanotubes, nanowires, and 2-D materials such as graphene will be covered.   The challenges in incorporating nanomaterials into devices will also be discussed. These methods will be compared to techniques used in the semiconductor industry and what challenges, technically and financially, exist for their widespread adoption will be addressed. Finally, examples of devices that use nanomaterials will be reviewed. The course will have some hands on demonstrations.

EECE.5600 Biomedical Instrumentation
Analysis and design of Biomedical Instrumentation systems that acquire and process biophysical signals. properties of biopotential signals and electrodes; biopotential amplifiers and signal processing; basic sensors and principles; medical imaging systems; electrical safety. Prerequisites: MATH.1320 and PHYS.1440.

EECE.5610 Computer Architecture and Design
Structure of computers, past and present, including: first, second, third and fourth generation. Combinational and sequential circuits. Programmable logic arrays. Processor design including: information formats, instruction set architecture, integer and real arithmetic, design of the CPU data path, hardwired and micro-programmed control, pipelined and superscalar architectures, Memory hierarchy including cache and virtual memory. Input-output systems, communication and bus control. Multiple CPU systems. Prerequisites: EECE.2650 and EECE.3170.

EECE.5620 VHDL/Verilog Synthesis and Design
Circuit and system representations including behavioral, structural, and physical descriptions using HDL. Modeling of short and narrow MOS transistors for submission applications. Over- view of CMOS technology including oxidation, epitaxy, deposition, ion implantation and diffusion essential for multilayer vias. 2-0 and 4-0 memory structures, I/O structures and PADS. System design including structural, hierarchy, regularity, modularity and programmable gate arrays.   RTL synthesis, layout and placement, design capture tools, including schematic, netlist, verification and simulation. Fast adders, subtractors, multipliers, dividers, ALUs, CPUs, RAMs, ROMs, row/column decoders, FIFOS, and FSMs with detailed examples. A RISC micro- controller, pipeline architecture including logic blocks, data paths, floor planning, functional verification and testing. Layout and simulation of chips as well as of PCs based on VHDL, Verilog, and HILO will be encouraged. Prerequisite: EECE.2650 and EECE.3650, or Permission of Instructor.

EECE.5650 Analog Devices and Techniques
A survey of analog devices and techniques, concentrating on operational amplifier design and applications. Operational amplifier design is studied to reveal the limitations of real op-amps, and to develop a basis for interpreting their specifications. Representative applications are covered, including: simple amplifiers, differential and instrumentation amplifiers, summers, integrators, active filters, nonlinear circuits, and waveform generation circuits. A design project is required. Prerequisite: EECE.3660.

EECE.568 Electro Optics and Integrated Optics
Introduction to optoelectronics and laser safety; geometrical optics; waves and polarization; Fourier optics; coherence of light and holography; properties of optical fibers; acousto-optic and electro-optic modulation; elementary quantum concepts and photon emission processes; optical resonators; Fabry Perot etalon; laser theory and types; review of semiconductor lasers and detectors; nonlinear optics. Prerequisite: EECE.3600.

EECE.5430 Theory of Communications
Information transmission and deterministic signals in time and frequency domains. Relationship between correlation and power or energy spectra. Statistical properties of noise. Spectral analysis and design of AM, FM and pulse modulation systems, continuous and discrete. AM, FM, and various pulse modulation methods, in the presence of noise. Digital modulation and demodulation technique. Prerequisites: EECE.3620 and EECE.3630 or EECE.5840 or equivalent.

EECE.5460 Communication Networks
An in depth survey of the elements of the modern computer based telecommunications system. Discussion of media used to transport voice and data traffic including twisted pair, baseband and broadband coaxial cable, fiber optic systems and wireless systems. Techniques for sending data over the media are presented including modems, baseband encoding, modulation and specific cases such as DSL, cable modems, telephone modems. Architecture and functionality of telephone system that serves as backbone for moving data, including multiplexing, switching, ATM, ISDN, SONET. Layered software architectures are discussed including TCP/IP protocol stack and the ISO/OSI seven layer stacks are examined in depth from data link protocols to transport protocols. LAN and WAN architectures including media access control (MAC) techniques are discussed for Ethernet, token ring and wireless LAN applications. Internetworking protocols and the role of repeaters, routers, and bridges. Voice over IP and state of the art applications. Prerequisites: EECE.3620 and EECE.3630 or EECE.5840 or Permission of Instructor.

EECE.5480 Coding and Information Theory
Probabilistic measure of information. Introduction to compression algorithms including L-Z, MPEG, JPEG, and Huffman encoding. Determination of the information handling capacity of communication channels and fundamental coding theorems including Shannon's first and second channel coding theorems. Introduction to error correcting codes including block codes and convolutional coding and decoding using the Viterbi algorithm. Applications of information theory and coding to advanced coding modulation such as Trellis Code Modulation (TCM) and turbo modulation. Prerequisites: EECE.3620, EECE.3630, EECE.5430, EECE.5840 or equivalent is desirable, programming in C, VB, or Matlab, or Permission of Instructor.

EECE.5500 Advanced Digital Systems Design
Design of logic machines, finite state machines, gate array designs, ALU and 4-bit CPU unit designs, microprogrammed systems. Hardware design of advanced digital circuits using XILINX. Application of probability and statistics for hardware performance and upgrading hardware systems. Laboratories incorporate specification, top down design, modeling, implementation and testing of actual advanced digital design systems hardware. Laboratories also include simulation of circuits using VHDL before actual hardware implementation and PLDs programming. Prerequisite: EECE.2650.

EECE.5530 Software Engineering
Introduces software life cycle models, and engineering methods for software design and development. Design and implementation, testing, and maintenance of large software packages in a dynamic environment, and systematic approach to software design with emphasis on portability and ease of modification. Laboratories include a project where some of the software engineering methods (from modeling to testing) are applied in an engineering example. Prerequisites: EECE.2160 and EECE.3220.

3. Concentration

A concentration is generally defined by a coordinated and approved sequence of at least four graduate courses. Each student can choose to work out a concentration either with the graduate coordinator or with his/her academic advisor. Completion of a specific concentration is not required for graduation. The course sequences in the concentrations serve as a starting point for establishing a program of study in consultation with the Graduate Coordinator or the student's academic/thesis advisor to meet his/her educational objectives. It is expected that the courses comprising the concentration will complement the work the student will undertake in fulfillment of the research requirement. A list of concentration areas and associated courses are shown below

4. Research Requirement

The research requirement may be fulfilled by completion of an MS Thesis, including registration for six credits of EECE.7430/EECE.7460 – MS Thesis Research, oral defense of the thesis and submission of the written document. Alternatively, the student may complete an MS Project, including registration for the course EECE.7330 – Advanced Graduate Project and submission of a written document. If the student chooses not to pursue the MS project, he or she may instead elect to complete a three-credit ECE technical elective. Note that the credits of EECE.7330 (no more than 3.0) can only be applied toward an MS degree with non-thesis option.

Areas of Concentration

Concentrations are sets of courses address specific topics in EE and CP. Students can choose to select a concentration that reflects their technical interests in preparation for working with a selected industry. As stated earlier, students are not required to choose a concentration.

Concentration courses in Electrical Engineering

Telecommunications

- EECE.5100 Digital Signal Processing
- EECE.5110 Medical Imaging Diagnosis
- EECE.5460 Computer Telecommunications
- EECE.5480 Coding and Information Theory
- EECE.5820 Wireless Communications
- EECE.5860 Stochastic Modeling in Telecommunications
- EECE.6170 Modeling and Simulation Techniques for Communication Networks
- EECE.6180 Performance of Wireless Communications Networks
- EECE.6610 Local Area /Computer Networking
- EECE.6850 Statistical Theory of Communications
- EECE.6870 Stochastic Estimation
- EECE.6880 Theoretical Acoustics

In addition to the required three core courses, three courses from the following list are recommended depending upon whether a thesis is selected or not.

Communications Engineering

- EECE.5330 Microwave Engineering
- EECE.5460 Computer Telecommunications
- EECE.5480 Coding and Information Theory
- EECE.5710 Radar Systems
- EECE.5820 Wireless Communications
- EECE.5860 Stochastic Modeling in Telecommunications
- EECE.6170 Modeling and Simulation Techniques for Communication Networks
- EECE.6180 Performance of Wireless Communications Networks
- EECE.6610 Local Area/Computer Networking
- EECE.6840 Time Series Analysis
- EECE.6850 Statistical Theory of Communications
- EECE.6870 Stochastic Estimation

Power and Energy Engineering

- EECE.5140 Power Systems Transmission
- EECE.5150 Power Electronics
- EECE.5160 Advanced Machine Theory
- EECE.5250 Power Systems Distribution
- EECE.5280 Alternative Energy Sources
- EECE.5290 Electric Vehicle Technology
- EECE.6150 Solid State Drives Systems
- EECE.6160 Computational Power Analysis

Opto-Electronics

- EECE.5080 Quantum Electronics for Engineers
- EECE.5180 Electromagnetic Materials for Optical Engineering
- EECE.5190 Engineering of Submicron Machines
- EECE.5230/4230 Introduction to Solid State Electronics
- EECE.5320 Computational Electromagnetics
- EECE.5830 Wave Propagation in Plasmas
- EECE.5900 Fiber Optic Communications
- EECE.5950 Solid State Electronics
- EECE.6070 Electromagnetics of Complex Media
- EECE.6080 Scattering and Diffraction of EM Waves
- EECE.6100 Optics for Information Processing
- PHYS.6310 Non-Linear Optics

Opto-Electronics is an option in cooperation with the Department of Physics, and may be pursued by students enrolled in the MS Eng in EE program. This option contains required and recommended courses designed to provide a fundamental background in optical devices and systems, as well as in optical physics and in the electro-optical properties of materials.

In addition to the required three core courses, students pursuing this option must take EECE.5680 Electro-Optics and Integrated Optics and two other courses from the above list.

Other concentrations in Electrical Engineering can be found from the clusters of courses specified as ECE certificates in the "Graduate Certificates" section.

EECE.5250 Power Systems Distribution
An intermediate course in analysis and operation of electrical power distribution systems using applied calculus and matrix algebra. Topics include electrical loads characteristics, modeling, metering, customer billing, voltage regulation, voltage levels, and power factor correction. The design and operation of the power distribution system components will be introduced: distribution transformers, distribution substation, distribution networks, and distribution equipment. Prerequisite: EECE.3550.

EECE.5270 Advanced VLSI Design Techniques
This course builds on the previous experience with Cadence design tools and covers advanced VLSI design techniques for low power circuits. Topics covered include aspects of the design of low voltage and low power circuits including process technology, device modeling, CMOS circuit design, memory circuits and subsystem design. This will be a research-oriented course based on team projects. Prerequisite: EECE.4690 or EECE.5020.

EECE.5280 Alternate Energy Sources
Photovoltaics: PV conversion, cell efficiency, cell response, systems and applications. Wind Energy conversion systems: Wind and its characteristics; aerodynamic theory of windmills; wind turbines and generators; wind farms; siting of windmills. Other alternative energy sources: Tidal energy, wave energy, ocean thermal energy conversion, geothermal energy, solar thermal power, satellite power, biofuels. Energy storage: Batteries, fuel cells, hydro pump storage, flywheels, compressed air. Prerequisite: Permission of Instructor.

EECE.5290 Electric Vehicle Technology
Electric vehicle VS internal combustion engine vehicle. Electric vehicle (EV) saves the environment. EV design, EV motors, EV batteries, EV battery chargers and charging algorithms, EV instrumentation and EV wiring diagram. Hybrid electric vehicles. Fuel cells. Fuel cell electric vehicles. The course includes independent work. Prerequisite: Permission of Instructor.

EECE.5310 RF Design
Two-port network parameters, Smith chart applications for impedance matching, transmission line structures like stripline, microstrip line and coaxial line, filter designs for low-pass, high-pass and band-pass characteristics, amplifier design based on s-parameters, bias network designs, one port and two port oscillator circuits, noise in RF systems. Prerequisite: EECE.3600.

EECE.5320 Computational Electromagnetics
Formulation of electromagnetic problems for computer solution. Variational principles in electromagnetics. Method of moments. Applications in electrostatics, wire antennas, wave- guides and cavities. Simple scattering problems. Finite difference methods. Finite element method. Prerequisite: EECE.4610.

EECE.5330 Microwave Engineering
An introductory course in the analysis and design of passive microwave circuits beginning with a review of time-varying electromagnetic field concepts and transmission lines. Smith Chart problems; single and double stub matching; impedance transformer design; maximally flat and Chebyshev transformers; microstrip transmission lines, slot lines, coplanar lines; rectangular and circular wave- guides; waveguide windows and their use in impedance matching; design of directional couplers; features of weak and strong couplings; microwave filter design; characteristics of low-pass, high- pass, band-pass, band-stop filter designs; two-port network representation of junctions; Z and Y parameters, ABCD parameters, scattering matrix; microwave measurements; measurement of VSWR, complex impedance, dielectric constant, attenuation, and power. A design project constitutes a major part of the course. Prerequisite: EECE.4610.

EECE.5410 Introduction to Biosensors
This course introduces the theory and design of biosensors and their applications for pathology, pharmacogenetics, public health, food safety civil defense, and environmental monitoring. Optical, electrochemical and mechanical sensing techniques will be discussed. Prerequisite: EECE.3650.

EECE.5170 MMIC Design and Fabrication*
The goal of MMIC design and fabrication is to prepare students for designing integrated circuits operating at GHz frequencies. The design is based on scattering parameters of the MESFETs and PHEMTs. The real challenge in this case is to relate S11, S12, S21 and S22 with the fabrication technology parameters such as channel conductance, transconductance and threshold voltages etc. This course not only covers RF design techniques but also the manufacturability and testability of the circuits at GHz frequencies, including packaging techniques. Prerequisite: EECE.3600 or Permission of Instructor.

EECE.5190 Engineering of Submicron Machines
Recently fabrication of Very Large Scale Integrated circuits has spun-off a new technology of micro-machines (MEMS) and sensors on a semiconductor wafer. These new devices are ideally located next to a microprocessor on the same wafer or a separate chip. The data transfer to and from a miniature machine, sensor or transducer is processed and controlled on site. Topics include design of mechanical, electrical and biological transducers; properties of electronic materials; pattern generation on a semiconductor wafer; interface of a micromachine and processor; applications and markets for submicron machines; their role in nanotechnology. Prerequisite: EECE.3650 or Permission of Instructor.

EECE.5200 Computer-Aided Engineering Analysis
Taylor series. Number systems and error. Difference and summation calculus. Interpolation. Definite integrals. Differential equation modeling and stability; Predictor-Corrector and Runge-Kutta methods. Orthogonal polynomials. Discrete transforms. Roots of polynomials. Zeros and stationary points of single variable functions. Gradient, quasi-Newton and conjugate gradient methods of optimization. Prerequisites: EECE.3640 and COMP.2340.

EECE.5210 Real-Time Digital Signal Processing
This course provides an introduction to real-time digital signal processing techniques using ADSP-21161, 21262, BF561, TS201S floating/fixed point processors. This is a practical course with 'hands on' training using the latest software development tools. First the core elements of the processor (computational units, data address generators, program sequencer) are examined in detail along with the relevant assembly code instructions. Internal and external memory configuration is also discussed. Advanced instructions are presented with a follow on lab on code optimization. The I/O peripherals (SPORTS, link ports, external port) are discussed in detail along with DMA operation between these peripherals and internal memory. Throughout the course, the various aspects of the software development process using the latest tools are discussed including setting up and building projects, assembly language programming, code debugging, simulation, tool support for code overlays and shared memory, and 'C' programming support. Hardware development tools, such as evaluation boards and ICE's are introduced with a follow on hardware/software lab where the student develops a simple interrupt driven application for a hardware target. Prerequisites: EECE.3620 and C or Assembly programming knowledge.

EECE.5230 Introduction to Solid-State Electronics
In this course the design of semiconductor devices and manufacturing technology is linked to the conventional and quantum transport of electrons in semiconductors. Topics covered: The electronic structure of the atom, wave-particle duality of moving electrons. Schrodinger equation for periodic crystalline structure. Band theory of semiconductors. E-k diagrams and Brillouin zones for quantum wires and quantum dots. Statistics of electrons and holes. Kinetic effects: electrical conductivity, Hall effect, magnetoresistance. Optical properties: photoconductivity, light absorption and emission. Thermal properties including thermal conductivity, recombination processes and role of defects. Prerequisite: EECE.3650 or Permission of Instructor.

EECE.5240 Programming Languages*
Syntax and semantics of programming languages. Fundamental concepts of control structures, modularity, scope of identifiers, recursion, and data structures. Examples of real programming languages such as FORTRAN, Pascal, LISP, APL, C++, and ADA. Prerequisite: FORTRAN, Pascal, or C.

Concentration courses in Computer Engineering

Computer Networking and Distributed Systems
- EECE.5580 World Wide Web programming
- EECE.5830 Network Design: Principles, Protocols and Applications
- EECE.5900 Fiber Optic Communications
- EECE.6570 High-Speed Integrated Networks: Design and Evaluations
- EECE.6580 Computer Network Security
- EECE.6590 Distributed Systems
- EECE.6600 Mobile IP Networking
- EECE.6610 Local Area/Computer Networking
- EECE.6660 Storage Area Networks

Computing and Embedded Systems Hardware and Architecture
- EECE.5020 VLSI Design
- EECE.5040 VLSI Fabrication
- EECE.5170 MMIC Design and Fabrication
- EECE.5500 Advanced Digital Systems Design
- EECE.5520 Microprocessors II and Embedded Systems
- EECE.5530 Software Engineering
- EECE.5570 Object Oriented Design
- EECE.5720 Embedded Real-time Systems
- EECE.5740 Advanced Logic Design
- EECE.5750 FPGA Logic Design Techniques
- EECE.6500 Advanced Computing Systems Hardware Architecture
- EECE.6520 Parallel and Multi-processor Architecture
- EECE.6560 Fault Tolerance Systems Design
- EECE.6630 Compiler Structures

Artificial and Machine Intelligence
- EECE.5110 Medical Imaging Diagnosis
- EECE.5520 Microprocessors II and Embedded Systems
- EECE.5530 Software Engineering
- EECE.5540 Voice Recognition, Processing and Computer Sound Drivers
- EECE.5560 Robotics
- EECE.5570 Object Oriented Design
- EECE.5720 Embedded Real-time Systems
- EECE.6510 Computer Vision
- EECE.6530 Artificial Intelligence and Machine Learning
- EECE.7500 Advanced Robotics and Machine Intelligence

Multimedia Digital Signal and Image Processing and Applications
- EECE.5020 VLSI Design
- EECE.5100 Digital Signal processing
- EECE.5110 Medical Imaging Diagnosis
- EECE.5210 Real Time DSP
- EECE.5530 Software Engineering
- EECE.5540 Voice Recognition, Processing and Computer Sound Drivers
- EECE.5720 Embedded Real-time Systems
- EECE.5810 Computer Vision and Digital Image Processing

Electrical & Computer Doctoral Programs

There are two types of doctoral degrees, the Doctor of Philosophy (Ph.D) and the Doctor of Engineering (D.Eng). The former is more research-oriented while the latter is more industrially-oriented. The Department offers both types of doctoral degrees in both EE and CP. The available degree programs are:

Doctor of Philosophy (Ph.D) Program in Electrical Engineering
Doctor of Philosophy (Ph.D.) Program in Computer Engineering
Doctor of Engineering (DEng) Program in Electrical Engineering
Doctor of Engineering (DEng) Program in Computer Engineering

The primary difference between the two types of doctoral programs is the requirement for 9 management credits for the D.Eng degrees. There may also be differences in the content of the dissertations.

Objective

The primary goal of the Doctoral Programs is to develop research engineers with the ability to produce new engineering knowledge. The program includes advanced graduate coursework in electrical engineering and allied subjects, a non-technical component (in the case of the D.Eng), and research culminating in a doctoral dissertation.

A complete description of the doctoral program is found in the Department of Electrical and Computer Engineering Doctoral Student Handbook which is updated annually and available from the department office.

Admission Requirements

Applicants must have a BS or MS degree in Electrical Engineering or Computer Engineering or their equivalent from a recognized College or University with an acceptable quality of prior academic work. Applicants must submit official transcripts of all prior undergraduate and graduate courses. Each applicant must submit an official report of Graduate Record Examination (GRE) scores for verbal, quantitative, and analytical examinations. The TOEFL exam is required for students from abroad whose native language is not English.

Plan of Study

Each student entering the program must develop a plan of study in consultation with his/her advisor.

Residency Requirement

One year of full-time residence is required of all students in the program.

Program Duration

The time for graduation for full-time students is expected to range from a minimum of three and a half years to a maximum of five years after BS Eng and a minimum of two and a half years to a maximum of four years after MS Eng.

EECE.5090 Linear Systems Analysis
Correlation and Circular convolutions. Concepts of orthogonality and Gramm-Schmidt orthogonalization procedure. Fourier series and Fourier transforms (FT): convergence properties; applications to linear systems including modulation, sampling and filtering. Hilbert transforms (HT) and analytic signals. Bilateral Laplace transforms (LT): convergence properties. Contour integration methods applied to FT, HT and LT. Discrete-time Fourier series and Fourier transforms including complex convolution: applications to linear systems. Discrete Fourier transforms and Fast Fourier algorithm. Z-transforms: convergence properties, solution of difference equations, application to linear systems. Correlation. Prerequisite: EECE.3620.

EECE.5100 Digital Signal Processing
Review of Z-Transforms and solutions of linear difference equations. Digital filter structures, parameter quantization effects and design techniques. FFT and Chirp Z-Transform methods. Discrete Hilbert Transforms, minimum-phase sequences and their application to Homomorphic Signal Processing and calculation of Complex Cepstrum. Prerequisite: EECE.3620, EECE.3630 preferred.

EECE.5110 Medical Imaging Diagnosis
This course covers the physics and electrical engineering aspects of how signals are acquired from which images will be formed, and the principal methods by which the signals are processed to form useful medical diagnostic images. Modalities studied include: x-rays, ultra- sound, computed tomography, and magnetic resonance imaging. The principles of signal processing via Fourier transform will be reviewed. Noise and other artifacts that degrade the medical diagnostic of images are considered. MATLAB is heavily used in simulation and verification. Prerequisite: EECE.3620.

EECE.5120 Mixed-Signal VLSI Design
The course covers a wide spectrum of topics related to challenges in modern VLSI design. Students will learn the skills of overcoming these problems when two opposing signal domains are integrated onto a single chip. Understanding physical layout representation and the effects of alternative layout solutions on circuit and system specifications is critical in modern designs. Students will learn to use the CAD tools widely used by the semiconductor industry for layout, schematic capture, advanced simulation, parasitic extraction, floor planning and place and route. specifically, the course provides a review of fundamentals of semiconductor components. In the next step, basic building blocks of digital and analog design are described. The course concludes with challenges of large scale integration under varying operation conditions. An individual project involving a layout design from specification to implementation is included.

EECE.5130 Control Systems
System representations, state variables, transfer functions, controllability and observability, phase variables, canonical variables, representation of nonlinear systems, Lagrange's equations, generalized cordinates, time response of linear systems, state transition matrix, Sylvester's expansion theorem, stability and state function of Liapunov, transient behavior estimation, optimal control, state function of Pontryagin, variational calculus, Hamilton Jacobi method, matrix Riccati equation, linear system synthesis. Prerequisite: EECE.4130.

EECE.5140 Integrated Power Systems
Power System Operations and Electricity Markets provide a comprehensive overview to understand and meet the challenges of the new competitive highly deregulated power industry. The course presents new methods for power systems operations in a unified integrated framework combining the business and technical aspects of the restructured power industry. An outlook on power policy models, regulation, reliability, and economics is attentively reviewed. The course lay the ground-work for the coming era of unbundling, open access, power marketing, self-generation, and regional transmission operations.

EECE.5150 Power Electronics
Design and performance analysis of rectifiers, inverters, DC chopper, AC voltage controllers, cycloconverters, and power supplies. The course includes a design project in the laboratory. Prerequisites: EECE.3550 and EECE.3660.

Graduate Courses

EECE.5020 VLSI Design
Introduction to CMOS circuits including transmission gate, inverter, NAND, NOR gates, MUXes, latches and registers. MOS transistor theory including threshold voltage and design equations. CMOS inverter's DC and AC characteristics along with noise margins. Circuit characterization and performance estimation including resistance, capacitance, routing capacitance, multiple conductor capacitance, distributed RC capacitance, multiple conductor capacitance, distributed RC capacitance, switching characteristics incorporating analytic delay models, transistor sizing and power dissipation. CMOS circuit and logic design including fan-in, fan-out, gate delays, logic gate layout incorporating standard cell design, gate array layout, and single as well as two-phase clocking. CMOS test methodologies including stuck-at-0, stuck-at-1, fault models, fault coverage, ATPG, fault grading and simulation including scan-based and self-test techniques with signature analysis. A project of modest complexity would be designed to be fabricated at MOSIS. Prerequisites: EECE.2650 and EECE.3650.

EECE.5040 VLSI Fabrication
Fabrication of resistors, capacitors, p-n junction and Schottky Barrier diodes, BJT's and MOS devices and Integrated circuits. Topics include: silicon structure, wafer preparation, sequential techniques in micro-electronic processing, testing and packaging, yield and clean room environments. MOS structures, crystal defects, Fick's laws of diffusion; oxidation of silicon, photolithography including photoresist, development and stripping. Metallization for conductors, Ion implantation for depletion mode and CMOS transistors for better yield speed, low power dissipation and reliability. Students will fabricate circuits using the DSIPL Laboratory. Prerequisite: EECE.3650.

EECE.5050 Microwave Electronics
Review of p-n junction theory, depletion layer width and junction capacitance, Schottky barrier diodes, pin diodes and applications in switches and phase shifters, varactors and step recovery diodes, tunnel diodes and circuits, Gunn devices and circuits, avalanche diodes, IMPATT, TRAPATT and BARRITT diodes, microwave bipolar junction transistors (BJT) and field effect transistors (FET), small signal amplifier design, new devices like HEMT and Si-Ge devices, traveling wave tubes and klystrons. Prerequisite: EECE.3650.

EECE.506 Antenna Theory and Design
An introduction to properties of individual antennas and arrays of antennas. Retarded potentials, dipoles of arbitrary length, radiation pattern, gain, directivity, radiation resistance. The loop antenna. Effects of the earth. Reciprocity, receiving antennas, effective length and area. Moment methods. Arrays: collinear, broadside, endfire. Array synthesis. Mutual coupling. Log-periodic and Yagi arrays. Radiation from apertures: the waveguide horn antenna, parabolic dish. Antenna noise temperature. Numerical software packages. Prerequisite: EECE.4610.

EECE.507 Electromagnetic Waves and Materials
This is a graduate core course, which serves the needs of students who study electromagnetics as a basis for a number of electromagnetic technologies including photonic technologies. Study of Electromagnetic Wave Interactions with Bounded Simple Media: transmission lines, Green's function, fibers, conducting waveguides and cavity resonators, Plane waves in Complex Electromagnetic Materials: plasmas, dispersive dielectrics, mixing formulas, optical waves in metals, super conductors, chiral media, crystals, magnetized plasma and time-varying media, layered and periodic media. Prerequisite: EECE.4610.

EECE.508 Quantum Electronics for Engineers
Introduction to the fundamental postulates of quantum theory: Planck's quantization hypothesis; wave-particle duality; time-dependent and time-independent Schrodinger's Equation; simple quantum mechanical systems. Radiation and quanta; quantization of the radiation field and cavity modes; absorption and emission of radiation; coherence functions; coherent states; importance of quantum fluctuations and quantum nature of light; laser amplifiers and amplifier nonlinearity; electromagnetics and quantum theory of laser oscillators; photons in semiconductors; semiconductor photon sources and detectors. Prerequisites: EECE.3630 and EECE.4610.

Transfer Credit

Up to 24 semester credits in graduate courses in Electrical Engineering and allied subjects are transferable to the doctoral program upon approval by the Doctor of Engineering Committee of the Department of Electrical and Computer Engineering.

Candidacy Requirements

1.   Qualifying Examination

The qualifying examination is a written exam which is conducted annually in late November. Students accepted to the Doctoral Program must take the qualifying examination within one year of their acceptance.

2.   Thesis Proposal and Oral Exam in Area of Concentration

Having passed the qualifying examination, a student may submit his/her dissertation proposal and defend the proposal before the Doctoral Committee. The proposal examination will also include an oral examination on topics connected with the student's area of research. On passing this examination, the student's name will be submitted for acceptance as a candidate for the Doctoral Degree. Admission to candidacy status does not guarantee the obtaining of the degree.

Academic Requirements

1.   Credit Requirements

The Doctor of Philosophy (Ph.D.) and Doctor of Engineering (D.Eng) degrees require completion of a minimum of 63 semester hours of academic credit beyond the Bachelor of Science degree. A typical program consists of the following:

Ph.D

ECE and Allied Subjects	42 (42)
Thesis	21 (22)
EECE.6010 Graduate Seminar	0
EECE.6020 Graduate Seminar	0
Total credit hours	63 (63)

D.Eng

ECE and Allied Subjects	33 (33)
Thesis	21 (22)
Non-Technical Component	9 (8)
EECE.6010 Graduate Seminar	0
EECE.6020 Graduate Seminar	0
Total credit hours	63 (63)

The Doctoral Program Coordinator of the Department of Electrical and Computer Engineering will assist students in selecting courses to meet the non-technical component of the Doctor of Engineering program.

2. Core Requirements

Required Core Courses for Ph.D or D.Eng in Electrical Engineering
- EECE.5070   Electromagnetic Waves and Materials
- EECE.5080   Quantum Electronics for Engineers
- EECE.5090   Linear Systems Analysis
- EECE.5130   Control Systems
- EECE.5150   Power Electronics
- EECE.5200   Computer-Aided Engineering Analysis
- EECE.5430   Theory of Communications
- EECE.5840   Probability and Random Processes
- EECE.5950   Solid State Electronics

Students in Electrical Engineering must take three of the above courses that may be pertinent to their area of concentration.

Required Core Courses for Ph.D or D.Eng in Computer Engineering
- EECE.5530   Software Engineering
- EECE.5610   Computer Architecture and Design
- EECE.5620   VHDL/Verilog Synthesis and Design
- EECE.5730   Operating Systems and Kernel Design
- EECE.5740   Advanced Logic Design

Students in Computer Engineering must take three of the above courses that may be pertinent to their area of concentration.

3. Concentration Requirement

Generally, a concentration is defined by a coordinated and approved sequence of at least four graduate courses. Each student can work out a concentration either with the doctoral coordinator or with his/her academic advisor. Completion of a concentration is mandatory. The course sequences in the concentrations serve as a starting point for establishing a program of study in consultation with the student's academic advisor to meet his/her educational objectives. It is expected that the courses comprising the concentration will complement the work the student will undertake in fulfillment of the research requirement. Indications of some of these concentrations are given under the programs of Master of Science in Engineering.

A concentration in electro-physics is also available.

4. Grade-Point Average (GPA) Requirement

To successfully complete the program, a student must achieve a cumulative grade-point average (GPA) of at least 3.25 in all course work.

5. Research Requirement and Dissertation

Each student is required to do a research internship for at least one year in industry, government, or at the University. The purpose of the internship is to place the student in a realistic engineering setting in which he/she will function as a responsible engineer and carry out the research work required for the dissertation. During the internship, the student must maintain close contact with his/her academic advisor. A written dissertation must be submitted and defended orally.

EECE.4820/EECE.5610 Computer Architecture and Design
Structure of computers, past and present, including: first, second, third and fourth generation. Combinational and sequential circuits. Programmable logic arrays. Processor design including: information formats, instruction set architecture, integer and real arithmetic, design of the CPU data path, hardwired and micro-programmed control, pipelined and superscalar architectures, Memory hierarchy including cache and virtual memory. Input-output systems, communication and bus control. Multiple CPU systems. Prerequisites: EECE.2650 and EECE.3170.

EECE.4830/EECE.5830 Network Design: Principles, Protocols and Applications
Covers design and implementation of network software that transforms raw hardware into a richly functional communication system. Real networks (such as the Internet, ATM, Ethernet, Token Ring) will be used as examples. Presents the different harmonizing functions needed for the interconnection of many heterogeneous computer networks. Internet protocols, such as UDP, TCP, IP, ARP, BGP and IGMP, are used as examples to demonstrate how internetworking is realized. Applications such as electronic mail and the WWW are studied. Topics include: inter-network architectures, high speed network service protocol implementation, addressing and address mapping, intra- and inter-domain routing, multicasting, mobility, auto-configuration, resource allocation, transport protocols, naming, client-server model, network programming interfaces (e.g., sockets, RMI, RPC, CORBA), secure transport protocols for high-speed networks and applications. Prerequisite: EECE.2160 or Programming Skills.

EECE.4840/EECE.5810 Computer Vision and Digital Image Processing
Introduces the principles and the fundamental techniques for Image Processing and Computer Vision. Topics include programming aspects of vision, image formation and representation, multiscale analysis, boundary detection, texture analysis, shape from shading, object modeling, stereo- vision, motion and optical flow, shape description and objects recognition (classification), and hardware design of video cards. AI techniques for Computer Vision are also covered. Laboratories include real applications from industry and the latest research areas. Prerequisites: EECE.2160 or EECE.3220, EECE.3620 or Permission of Instructor.

EECE.4900/EECE.5900 Fiber Optic Communications
Optical fiber; waveguide modes, multimode vs. single mode; bandwidth and data rates; fiber losses; splices, couplers, connectors, taps and gratings; optical transmitters; optical receivers; high speed optoelectronic devices; optical link design; broadband switching; single wavelength systems; wavelength division multiplexing; fiber amplifiers. Prerequisites: EECE.3600 and EECE.3620 or Permission of Instructor.

EECE.4910 Industrial Experience
This three credit course is for co-op or industrial experience. It may be taken three times and the co-op internship should be for at least 500 hours in order to be eligible for credit. Only 3 credits may be used toward the BS Eng in CpE or EE degree. Registration for this course is conditional on the approval of the Department Co-op coordinator. A grade of Satisfactory or Unsatisfactory is given. Prerequisite: Permission of Instructor.

EECE.4920 Industrial Experience II
Industrial work experience by permission of coordinator only.

EECE.4990 Capstone Project
The purpose of the CAPSTONE Project is to provide the student with a design experience which resembles entry level engineering assignments. It is expected that the project encompasses a minimum of three technical areas within the CpE or EE discipline, and include some aspects of each step in the development of a marketable product i.e. Research, Design and Development, Manufacture, Marketing and Service. A formal technical report must be submitted prior to the submission of a course grade. Prerequisites: EECE.3990 and EECE.4000.

EECE.4690/EECE.5020 VLSI Design

Introduction to CMOS circuits including transmission gate, inverter, NAND, NOR gates, MUXes, latches and registers. MOS transistor theory including threshold voltage and design equations. CMOS inverter's DC and AC characteristics along with noise margins. Circuit characterization and performance estimation including resistance, capacitance, routing capacitance, multiple conductor capacitance, distributed RC capacitance, multiple conductor capacitance, distributed RC capacitance, switching characteristics incorporating analytic delay models, transistor sizing and power dissipation. CMOS circuit and logic design including fan-in, fan-out, gate delays, logic gate layout incorporating standard cell design, gate array layout, and single as well as two-phase clocking. CMOS test methodologies including stuck-at-0, stuck-at-1, fault models, fault coverage, ATPG, fault grading and simulation including scan-based and self-test techniques with signature analysis. A project of modest complexity would be designed to be fabricated at MOSIS. Prerequisites: EECE.2650 and EECE.3650.

EECE.4700/EECE.5040 VLSI Fabrication

Fabrication of resistors, capacitors, p-n junction and Schottky Barrier diodes, BJT's and MOS de- vices and Integrated circuits. Topics include: silicon structure, wafer preparation, sequential techniques in micro-electronic processing, testing and packaging, yield and clean room environments. MOS structures, crystal defects, Fick's laws of diffusion; oxidation of silicon, photolithography including photoresist, development and stripping. Metallization for conductors, Ion implantation for depletion mode and CMOS transistors for better yield speed, low power dissipation and reliability. Students will fabricate circuits using the DSIPL Laboratory. Prerequisite: EECE.3650.

EECE.4730/EECE.5150 Power Electronics

A one-semester course with emphasis on the engineering design and performance analysis of power electronics converters. Topics include: power electronics devices (power MOSFETs, power transistors, diodes, silicon controlled rectifiers SCRs, TRIACs, DIACs and Power Darlington Transistors), rectifiers, inverters, ac voltage controllers, dc choppers, cycloconverters, and power supplies. The course includes a project, which requires that the student design and build one of the power electronics converters. A demonstrative laboratory to expose the students to all kinds of projects is part of the course. Prerequisites: EECE.3550 and EECE.3660.

EECE.4740/EECE.5760 Principles of Solid-State Devices

Principles of Solid State Devices: Crystal properties and growth of semi-conductors, atoms and electrons, Bohr's model, quantum mechanics, bonding forces and energy bands in solids, charge carriers in semiconductors, drift of carriers in electric and magnetic fields, carrier lifetime and photo- conductivity, junctions, forward and reverse bias, reverse bias breakdown (Zener effect), tunnel diodes, photodiodes, LED, bipolar junction transistors, field effect transistors. Prerequisite: EECE.3650.

EECE.4800/EECE.5520 Microprocessors II and Embedded Systems

This course provides a continuation of the study of microprocessors begun in EECE.3170. Topics include CPU architecture, memory interfaces and management, coprocessor interfaces, bus concepts, bus arbitration techniques, serial I/O devices, DMA, interrupt control devices. Focus will be placed on the design, construction, and testing of dedicated microprocessor systems (static and real-time). Hardware limitations of the single-chip system will be investigated along with micro- controllers, programming for small systems, interfacing, communications, validating hardware and software, microprogramming of controller chips, and design methods and testing of embedded systems. Laboratories directly related to microprocessor functions and its interfaces. Prerequisites: EECE.3110, EECE.3170, and EECE.3650.

EECE.4810/EECE.5730 Operating Systems and Kernel Design

Covers the components, design, implementation, and internal operations of computer operating systems. Topics include basic structure of operating systems, Kernel, user interface, I/O device management, device drivers, process environment, concurrent processes and synchronization, inter-process communication, process scheduling, memory management, deadlock management and resolution, and file system structures. laboratories include examples of components design of a real operating systems. Prerequisite: EECE.2160 or Programming Skills.

Graduate Certificates

Graduate certificate programs are ideal for bachelor's degree-prepared engineers who wish to continue their studies without making the commitment of a master's program. Students may want to brush-up on new developments in their field or investigate another specialty. Certificates are earned by taking four courses from a list associated with each certificate.

Electrical and Computer Engineering
- Communications engineering
- Field Programmable Gate Array
- Microwave and wireless engineering
- VLSI and microelectronics

Interdisciplinary
- Biomedical engineering
- Energy conversion
- Integrated engineering systems
- Nanotechnology
- Photonics and optoelectronics
- Telecommunications

Each of these certificates are described below and include the name and contact information of the certificate coordinator.

Communications Engineering Certificate
Electrical and Computer Engineering Department
Contact: Dr. Kavitha Chandra, 978-934-3356, kavitha_chandra@uml.edu

This certificate provides a fundamental background in the understanding of information transmission, statistical properties of signals and noise, and both analog and digital modulation/demodulation techniques. Advanced topics in modern communications and the characterization of communication channels are covered in optional courses in coding, error correction, information measures, stochastic system modeling and wireless communications. The holder of the certificate will have both analytical and practical competence to contribute significantly to the design and development of new and updated communications systems.

Required Courses:
- EECE.5430   Communications Theory
- EECE.5840   Probability and Random Processes

Elective Courses: (Choose two of the following)
- EECE.5480   Coding and Information Theory
- EECE.5820   Wireless Communication
- EECE.6180   Performance of Wireless Communications Networks
- EECE.6850   Statistical Communication Theory
- EECE.6870   Applied Stochastic Estimation

Field Programmable Gate Array
Electrical and Computer Engineering Department
Contact: Dr. Yan Luo, 978-934-2592, Yan_Luo@uml.edu

The 12-credit certificate is a valuable credential for engineering professionals in the private and public sectors who wish to master the theoretical and practical skills in FPGA development and applications. Certificate holders will acquire additional academic credentials to advance within their organization or to change their career paths and improve their competitive position in the job market. For many employees working in the technical and scientific fields without any FPGA background, the GCFPGA will provide them with the knowledge needed for effectively applying FPGA's in the design of mission-critical and reliable digital systems.

Please note, if you are a BAE employee, there is a fixed set of six courses you must complete to obtain the GCFPGA and to be recognized by BAE systems internally as proficient in FPGA technologies.

Required Three 3-Credit Courses:
- EECE.5750   FPGA Logic Design Techniques
- EECE.5620   VHDL/Verilog Synthesis and Design
- EECE.5770   Verification of Digital Systems

Elective Courses: (Choose one of the following)
- EECE.6510   Advanced Embedded System Design and FPGA
- EECE.5780   Modeling and Implementation of Digital System using MATLAB
- EECE.6540   Heterogeneous Computing
- EECE.5500   Advanced Digital System Design
- EECE.5520   Microprocessor Systems II and Embedded System Design
- EECE.5530   Software Engineering
- EECE.5610   Computer Architecture & Design
- EECE.5720   Embedded Real-Time System
- EECE.7150   Special Topics

Microwave and Wireless Engineering Certificate
Electrical and Computer Engineering Department
Contact: Dr. Tenneti C. Rao, 978-934-3323, tenneti_rao@uml.edu

Wireless technologies are of increasing importance in a variety of personal communications and control applications. The certificate is open to students who have an interest in learning the fundamentals and engineering applications of radio wave and micro-wave devices and systems. The integrated set of courses offers graduate level skills and knowledge which will provide a background for those wishing to participate in this rapidly expanding field. The certificate is open to students with a BS degree in electrical engineering or in related disciplines such as physics or electronics engineering technology with an appropriate background in electromagnetics.

Required Courses:
- EECE.5310   Radio Frequency (RF) Design
- EECE.5320   Microwave Engineering
- EECE.5820   Wireless Communications

Elective Courses: (Choose one of the following)
- EECE.5060   Antenna Design
- EECE.5710   Radar System
- EECE.6180   Performance of Wireless Communication Networks

EECE.4450/EECE.5650 Analog Devices & Techniques
A survey of analog devices and techniques, concentrating on operational amplifier design and applications. Monolithic operational amplifier design is studied both from the point of view of the op-amp designer whose goal is to optimize performance, as well as the application engineer who needs to understand the limitations of real op-amps, and to be able to interpret their specifications. Representative applications may include: simple amplifiers, differential and instrumentation amplifiers, summers, integrators, active filters, nonlinear circuits, and waveform generation circuits. A design project is required. Prerequisite: EECE.3660.

EECE.4500/EECE.5500 Advanced Digital Systems Design
Design of logic machines, finite state machines, gate array designs, ALU and 4 bit CPU unit designs, micro- programmed systems. Hardware design of advanced digital circuits using XILINX. Application of probability and statistics for hardware performance and upgrading hardware systems. Laboratories incorporate specification, top down design, modeling, implementation and testing of actual advanced digital design systems hardware. Laboratories also include simulation of circuits using VHDL before actual hardware implementation and PLDs programming. Prerequisite: EECE.2650.

EECE.4530/EECE.5530 Software Engineering
Introduces software life cycle models, and engineering methods for software design and development. Design and implementation, testing, and maintenance of large software packages in a dynamic environment, and systematic approach to software design with emphasis on portability and ease of modification. Laboratories include a project where some of the software engineering methods (from modeling to testing) are applied in an engineering example. Prerequisites: EECE.2160 and EECE.3220.

EECE.4600/EECE.5600 Medical Instrumentation
Analysis and design of Biomedical Instrumentation systems that acquire and process biophysical signals. properties of biopotential signals and electrodes; biopotential amplifiers and signal processing; basic sensors and principles; medical imaging systems; electrical safety. Prerequisites: MATH.1320 and PHYS.1440.

EECE.4610 Engineering Electromagnetics II
Continuation of Magnetostatics, Maxwell's Equations for Time-varying Fields, plane waves: time-harmonic fields, polarization, current flow in good conductors and skin effect, power density and Poynting vector, wave reflection and transmission; Snell's Law, fiber optics, Brewster angle, radiation and simple antennas, electromagnetic concepts involved in a topical technology in development. Prerequisites: EECE.3600.

EECE.4620/EECE.5060 Antenna Theory and Design
An introduction to properties of individual antennas and arrays of antennas. Retarded potentials, dipoles of arbitrary length, radiation pattern, gain, directivity, radiation resistance, will be covered. The loop antenna. Effects of the earth. Reciprocity, receiving antennas, effective length and area. Moment methods. Arrays: collinear, broadside, endfire. Array synthesis. Mutual coupling. Log-periodic and Yagi arrays. Radiation from apertures, including the waveguide horn antenna. Numerical software packages will be used throughout the course. A design project is required in the course. Prerequisite: EECE.4610.

EECE.4680/EECE.5680 Electro-optics and Fiber Optics
Introduction to optoelectronics and laser safety; geometrical optics; waves and polarization; Fourier optics; coherence of light and holography; properties of optical fibers; acousto-optic and electro-optic modulation; elementary quantum concepts and photon emission processes; optical resonators; Fabry Perot etalon; laser theory and types; review of semiconductor lasers and detectors; nonlinear optics. Prerequisite: EECE.3600.

EECE.4230/EECE.5230 Introduction to Solid-State Electronics
A design of semiconductor device and manufacturing technology is linked to the solid state physics principles in this course. Topics covered: The electronic structure of the atom, wave-particle duality of moving electrons. Schrodinger equation for periodic crystalline structure. Band theory of semiconductors. Brillouin zones. Statistics of electrons and holes. Kinetic effects: electrical conductivity, Hall effect, magnetoresistance. Optical properties: photoconductivity, light absorption and emission. Thermal properties including thermal conductivity, thermo EMF, recombination processes and role of defects. Prerequisite: EECE.3650 or Permission of Instructor.

EECE.4270/5270 Advanced VLSI Design Techniques
This course builds on the previous experience with Cadence design tools and covers advanced VLSI design techniques for low power circuits. Topics covered include aspects of the design of low voltage and low power circuits including process technology, device modeling, CMOS circuit design, memory circuits and subsystem design. This will be a research-oriented course based on team projects. Prerequisite: EECE.4690 or EECE.5020.

EECE.4280/EECE.5280 Alternate Energy Sources Photovoltaics
PV conversion, cell efficiency, cell response, systems and applications. Wind Energy conversion systems: Wind and its characteristics; aerodynamic theory of windmills; wind turbines and generators; wind farms; siting of windmills. Other alternative energy sources: Tidal energy, wave energy, ocean thermal energy conversion, geothermal energy, solar thermal power, satellite power, biofuels. Energy storage: Batteries, fuel cells, hydro pump storage, flywheels, compressed air. Prerequisite: Permission of Instructor.

EECE.4290/EECE.5290 Electric Vehicle Technology
Electric vehicle VS internal combustion engine vehicle. Electronic vehicle (EV) saves the environment. EV design, EV motors, EV batteries, EV battery chargers and charging algorithms, EV instrumentation and EV wiring diagram. Hybrid electric vehicles. Fuel cell electric vehicles. The course includes independent work. Prerequisite: Permission of Instructor.

EECE.4310/EECE.5310 RF Design
Two-port network parameters, Smith chart applications for impedance matching, transmission line structures like stripline, microstrip line and coaxial line, filter designs for low-pass, high-pass and band-pass characteristics, amplifier design based on s-parameters, bias network designs, one port and two port oscillator circuits, noise in RF systems. Prerequisite: EECE.3600.

EECE.4350/5320 Computational Electromagnetics
Formulation of electromagnetic problems for computer solution. Variational principles in electromagnetics. Method of moments. Applications in electrostatics, wire antennas, waveguides and cavities. Simple scattering problems. Finite difference methods. Finite element method. Prerequisite: EECE.4610.

EECE.4410/5410 Introduction to Biosensors
This course introduces the theory and design of biosensors and their applications for pathology, pharmacogenetics, public health, food safety civil defense, and environmental monitoring. Optical, electrochemical and mechanical sensing techniques will be discussed. Prerequisite: EECE.3650.

EECE.4440/EECE.5250 Power Systems Distribution
An intermediate course in analysis and operation of electrical power distribution systems using applied calculus and matrix algebra. Topics include electrical loads characteristics, modeling, metering, customer billing, voltage regulation, voltage levels, and power factor correction. The design and operation of the power distribution system components will be introduced: distribution transformers, distribution substation, distribution networks, and distribution equipment. Prerequisite: EECE.3550.

VLSI & Microelectronics Certificate
Department of Electrical & Computer Engineering
Contact: Dr. Kanti Prasad, 978-934-3326, kanti_prasad@uml.edu

The purpose of this certificate program is to provide essential background in solid state physical electronics and very large scale integrated (VLSI) circuit fabrication. These courses, combined with two electives, will provide a customized background to the subject but with sufficient depth in an area of choice to provide tangible useful expertise.

Required Courses: (Choose two of the following)
- EECE.5020   VLSI Design
- EECE.5950   Solid State Electronics
- EECE.5040   VLSI Fabrication
- EECE.5080   Quantum Electronics for Engineers

Elective Courses: (Choose two of the following)
- EECE.5020   VLSI Design
- EECE.5050   Microwave Electronics
- EECE.5070   Electromagnetic Waves and Materials
- EECE.5080   Quantum Electronics for Engineers
- EECE.5170   MMIC Design and Fabrication
- EECE.5650   Analog Devices
- EECE.5680   Electro Optics and Integrated Optics

Biomedical Engineering Certificate
Electrical & Computer Engineering Department
Contact: Dr. Mufeed Mah'd, 978-934-3317, mufeed_mahd@uml.edu

Image data are of increasing importance in Biomedical Engineering and Biotechnology. The application of microelectronic circuitry, high performance processors, and improved algorithms based on advanced mathematics has resulted in innovative new methodologies to acquire and process image data, permitting visualization, quantification, and functional analysis of tissues and organs. The Biomedical Engineering Graduate Certificate is a multidisciplinary program, spanning courses in several departments in the College of Engineering including Departments of Electrical and Computer Engineering, Plastic Engineering, Chemical and Nuclear Engineering, as well as the Biomedical Engineering and Biotechnology program. The certificate provides an excellent opportunity for educational experience to learn the principles and applications of imaging technology. It is a coordinated program of courses, seminars, and laboratory experiences jointly offered by the participating departments.

Required Courses:
EECE.5110 Medical Imaging Diagnosis
BMBT.5000 Introduction to Biomedical Engineering and Biotechnology

Elective Courses: (Choose two of the following)
- EECE.5100 Digital Signal Processing
- BMBT.5000 Introduction to Biomedical Engineering and Biotechnology
- BMBT.5120 Medical Image Processing
- BMBT.5160 Principles of Nuclear Magnetic Resonance Imaging

- BMBT.5170 Embedded System Design in Medical Systems
- PUBH.5310 Occupational Biomechanics
- ENGY.5420 Microscopy of Advanced Materials
- PLAS.5750 Biomaterials I
- EECE.5600 Biomedical Instrumentation
- BMBT.5120 Medical Image Processing
- BMBT.5130 Biomedical Analytics and Informatics
- BMBT.5160 Basic Principles of Magnetic Resonance Imaging

Energy Conversion Certificate
Electrical and Computer Engineering Department
Contact: Dr. Mufeed Mahd, 978-934-3027, mufeed_mahd@uml.edu

Energy conversion is a discipline that spans across three departments: Electrical, Mechanical and Chemical & Nuclear Engineering. Interest is rising for practical applications in the housing industry to supply houses with clean sources of energy to meet electrical supply needs, as well as for space heating/ cooling. All renewable energy sources will be considered (e.g. wind energy and photovoltaics). Information about batteries, battery charging stations, battery chargers and energy conversion devices (such as rectifiers, inverters, choppers, controllers) is presented as related to the development of low emission vehicles.

Choose four of the following courses:
- EECE.5150   Power Electronics
- EECE.5250   Power Systems Distribution
- EECE.5280   Alternative Energy Sources
- EECE.5290   Electric Vehicle Technology
- MECH.5210   Fundamentals of Solar Energy Engineering
- MECH.5270   Solar Energy Engineering

Integrated Engineering Systems Certificate
Applied Physics, Computer Engineering, Computer Science, Electrical Engineering, Materials Engineering, Mechanical Engineering, Plastics Engineering Departments
Contact: Dr. Xuejun Lu, 978-934-3359, Xuejun_Lu@uml.edu

As companies increasingly undertake engineering projects that bring together a wide range of disciplines for manufacturing an integrated product, it is often necessary to assemble teams of experts in these various disciplines, and prepare managers who have a fundamental, overall understanding of several different engineering areas. The certificate is designed to respond to the need for trained professionals who are responsible for managing complex engineering systems integrating algorithms, information, software and hardware. Completion of certificate courses in areas complementary to the individual's specific training will serve as an important starting point for engineering managers (and prospective managers) who need to solve complex interdisciplinary problems at the interfaces of electrical, computer, mechanical, materials engineering, and computer science and applied physics.

The program consists of six clusters: 1) Applied Physics; 2) Computer Engineering; 3) Computer Science; 4) Electrical Engineering; 5) Materials Engineering; and 6) Mechanical Engineering. Within each cluster, there are a number of carefully selected courses ranging from introductory graduate level to more advanced, specialized electives.

EECE.4030 Microwave Engineering
An introductory course in the analysis and design of passive microwave circuits beginning with a review of time-varying electromagnetic field concepts and transmission lines. Smith Chart problems; single and double stub matching; impedance transformer design; maximally flat and Chebyshev transformers; microstrip transmission lines, slot lines, coplanar lines; rectangular and circular waveguides; waveguide windows and their use in impedance matching; design of directional couplers; features of weak and strong couplings; microwave filter design; characteristics of low-pass, high-pass, band-pass, band-stop filter designs; two-port network representation of junctions; Z and Y parameters, ABCD parameters, scattering matrix; microwave measurements; measurement of VSWR, complex impedance, dielectric constant, attenuation, and power. A design project constitutes a major part of the course. Prerequisite: EECE.4610.

EECE.4110/EECE.5110 Medical Diagnostic Imaging
This course covers the physics and electrical engineering aspects of how signals are acquired from which images will be formed, and the principal methods by which the signals are processed to form useful medical diagnostic images. Modalities studied include: x-rays, ultra-sound, computed tomography, and magnetic resonance imaging. The principles of signal processing via Fourier transform will be reviewed. Noise and other artifacts that degrade the medical diagnostic of images are considered. MATLAB is heavily used in simulation and verification. Prerequisite: EECE.3620.

EECE.4130 Linear Feedback Systems
Concepts of feedback; open loop and closed loop systems. Feedback in electrical and mechanical systems. Mathematical models of systems and linear approximations. Transfer functions of linear systems, block diagrams and signal flow graphs. Sensitivity, control of transient response, disturbance signals. Time domain performance: steady state errors, performance indices. Stability related to s- plane location of the roots of the characteristic equation. Routh-Hurwitz criterion. Graphical analysis techniques: root locus, frequency response as polar plot and Bode diagrams. Closed loop frequency response. A control system design project is included in the course. Prerequisites: EECE.3620 and EECE.3640.

EECE.4140/5140 Integrated Power Systems
Power System Operations and Electricity Markets provide a comprehensive overview to understand and meet the challenges of the new competitive highly deregulated power industry. The course presents new methods for power systems operations in a unified integrated framework combining the business and technical aspects of the restructured power industry. An outlook on power policy models, regulation, reliability, and economics is attentively reviewed. The course lay the groundwork for the coming era of unbundling, open access, power marketing, self-generation, and regional transmission operations.

EECE.4180 Wireless Communications
Cellular systems and design principles, co-channel and adjacent channel interference, mobile radio propagation and determination of large scale path loss, propagation mechanisms like reflection, diffraction and scattering, outdoor propagation models, Okumura and Hata models, small scale fading and multipath, Doppler shift and effects, statistical models for multipath, digital modulation techniques QPSK, DPSK, GMSK, multiple access techniques, TDMA, FDMA, CDMA, spread spectrum techniques, frequency hopped systems, wireless systems and worldwide standards. Prerequisite: EECE.3600.

EECE.4210/EECE.5210 Real-Time Digital Signal Processing
This course provides an introduction to real-time digital signal processing techniques using ADSP-21161, 21262, BF561, TS201S floating/fixed point processors. This is a practical course with 'hands on' training using the latest software development tools. First the core elements of the processor (computational u nits, data address generators, program sequencer) are examined in detail along with the relevant assembly code instructions. Internal and external memory configuration is also discussed. Advanced instructions are presented with a follow on lab on code optimization. The I/O peripherals (SPORTS, link ports, external port) are discussed in detail along with DMA operation between these peripherals and internal memory. Throughout the course, the various aspects of the software development process using the latest tools are discussed including setting up and building projects, assembly language programming, code debugging, simulation, tool support for code overlays and shared memory, and 'C' programming support. Hardware development tools, such as evaluation boards and ICE's are introduced with a follow on hardware/software lab where the student develops a simple interrupt driven application for a hardware target. Prerequisites: EECE.3620 and C or Assembly programming knowledge.

EECE.3630 Introduction to Probability and Random Processes
This course employing probabilistic methods of signal and system analysis (an extension of EECE.3620) considers the random nature of the world faced by electrical engineers. The course addresses the issues of the nature and characterization of random events, especially noise and its effect on systems. The course is divided into three parts, 1) Introduction to discrete and continuous probability 2) Introduction to statistical methods and 3) random signals and noise and the response of linear systems to random signals. There will be frequent use of Monte-Carlo simulation techniques on the computer to allow students to verify theory and to learn the important technique of simulation. Applications of theory to manufacturing and reliability, noise analysis, spectral analysis, data communication, data collection, and system design will be presented. Prerequisite: EECE.3620.

EECE.3640 Engineering Mathematics
The course covers the main topics in complex variables and applications including: Complex numbers, Argand plane, derivatives of complex numbers, limits and continuity, derivative and Cauchy Riemann conditions, analytic functions, integration in the complex plane, Cauchy's integral formula, infinite series for complex variables, Taylor series, Laurent series, residue theory, evaluation of integrals around indented contours. Additionally, the following topics in linear algebra will be covered: Linear vector spaces, matrices and determinants, eigenvalues and eigenvectors. Prerequisite: MATH.2360 Eng Differential Equations

EECE.3650 Electronics I
A brief introduction to solid-state physics, leading to discussion of physical characteristics of p-n junction diodes, bipolar junction transistors, and field-effect transistors: active, saturated, and cut-off models of bipolar transistors and triode, constant current, and cut-off models of MOSFETs. Circuit models for di-odes, and diode applications. Circuit models for transistors, and transistor applications in bipolar and MOS digital circuits and low-frequency amplifier circuits. Analysis of digital circuits and linear circuits based on application of circuit models of devices and circuit theory. Prerequisites: EECE.2020, PHYS.1440 and either Calculus III or Differential equations. Co-requisite: EECE.3110.

EECE.3660 Electronics II
A continuation of EECE.365 with discussion of differential amplifiers, operational amplifiers and op amp applications, transistor amplifiers at very high frequencies; direct-coupled and band pass amplifiers; small and large signal amplifiers; feedback amplifiers and oscillators. Active filters, wave form generation circuits including Schmitt trigger, multiplexers, and A/D and D/A converters. Circuit design employing integrated circuit operational amplifiers and discrete devices. Circuit analysis using SPICE. An electronic design project constitutes a major part of the course. Prerequisite: EECE.3650. Co-requisite: EECE.3120.

EECE.3990 Capstone Proposal
This course discusses and presents the non-technical tools and procedures for bringing a potential product from the idea or basic concept stage through final design and to market. Fundamentals of market research, product safety and liability concerns, necessary technical communication skills. Economic concerns, patent, application procedures, design procedures and people skills necessary to be part of an engineering team. Prerequisites: EECE.3120, EECE.3170, EECE.3630, EECE.3660, and less than 30 credits remaining at the time of registration to complete major. Co-requisite: EECE.4000

EECE.4000 Engineering Topics
This course introduces to the seniors developing the capstone proposal important concepts such as economics, environmental, sustainability, manufacturability, ethical, health, safety, social and political constraints and how these are related to the overall engineering processes. These will be used as an integral part of their capstone projects. Co-requisite: EECE.3990.

EECE.4090/EECE.4100/4120 Directed Studies
The purpose of this course is to provide an opportunity for qualified ECE students to investigate specific areas of interest. The actual project undertaken may be software or hardware oriented. The most important characteristics of the projects are that the end results represent independent study and that they are research and development oriented, and that they are accomplished in an engineering environment. Design reviews and progress reports are expected for each project. A final formal report to be permanently filed in the ECE Department is required for each project. Prerequisites: at least three courses from EECE.3550, EECE.3600, EECE.3620, EECE.3650, and EECE.3660.

Students must successfully complete four courses, one or two of which may be taken in their area of expertise. The remaining courses must be taken in separate and different cluster areas. Courses are selected in consultation with one (or more) graduate program coordinators to best meet the student's needs in terms of background, interests, and work requirements. It may be necessary for students to take prerequisite course(s) if they do not have appropriate backgrounds for a particular cluster course.

Cluster Areas and Designated Courses:

Applied Physics
- PHYS.5530 Electromagnetism I
- PHYS.5540 Electromagnetism II
- PHYS.5400 Image Processing (4 credits)
- PHYS.5780 Integrated Optics: Wave Guide and Lasers
- PHYS.5350 Introduction of Quantum Mechanics I
- PHYS.5470 Laser Physics and Applications
- PHYS.5380 Physical Optics and Waves
- PHYS.5770 Solid State Electronic and Opto-Electronic Devices
- PHYS.5210 Statistical Thermodynamics

Computer Engineering
- EECE.5500 Advanced Digital System Design
- EECE.5610 Computer Architecture Design
- EECE.5810 Computer Vision and Digital Image Processing
- EECE.5100 Digital Signal Processing
- EECE.5720 Embedded Real-Time Systems
- EECE.5750 FPGA Logic Design Techniques
- EECE.5520 Microprocessors Systems II and Embedded Systems
- EECE.5820 Wireless Communications
- EECE.5730 Operating Systems and Kernel Design
- EECE.5210 Real Time DSP
- EECE.5020 VLSI Design
- EECE.5040 VLSI Fabrication

Computer Science
- COMP.5610 Computer Security I
- COMP.5620 Computer Security II
- COMP.5630 Data Communications I
- COMP.5640 Data Communications II
- COMP.5490 Mobile Robots
- COMP.5150 Operating Systems I
- COMP.5160 Operating Systems II
- COMP.5480 Robot Design

Electrical Engineering

- EECE.5280 Alternative Energy Sources
- EECE.5060 Antenna Theory and Design
- EECE.5320 Computational Electromagnetics
- EECE.5130 Control Systems
- EECE.5290 Electric Vehicle Technology
- EECE.5070 Electromagnetic Waves and Materials
- EECE.5190 Engineering of Submicron Machines
- EECE.5900 Fiber Optic Communications and Networks
- EECE.5430 Theory of Communication
- EECE.5090 Linear System Analysis
- EECE.5050 Microwave Electronics
- EECE.5330 Microwave Engineering
- EECE.5150 Power Electronics
- EECE.5840 Probability and Random Processes
- EECE.5710 Radar Systems
- EECE.5170 MMIC Design and Fabrication

Materials Engineering

- PLAS.5440 Advanced Plastics Materials
- CHEN.5060 Interfacial Science and Engineering and Colloids
- PLAS.5030 Mechanical Behavior of Polymers
- CHEN.5230 Nanodevices and Electronic Materials
- CHEN.5410 Nanostructural Characterization by SEM, TEM, and AFM
- PLAS.5180 Plastics Product Design

Mechanical Engineering

- MECH.5120 Applied Finite Element Analysis
- MECH.5710 Concurrent Engineering and Quality
- MECH.5230 Cooling of Electronic Equipment
- MECH.5740 Design for Reliability Engineering
- MECH.5160 Experimental Modal Analysis
- MECH.5240 Fundamentals of Acoustics
- MECH.5750 Industrial Design of Experiments
- MECH.5910 Mechanical Behavior of Materials
- MECH.5150 Modal Analysis- Theoretical Methods
- MECH.5790 Robotics
- MECH.5620 Solid Mechanics
- MECH.5270 Solar Systems Engineering
- MECH.5500 Vibrations

EECE.3170 Microprocessor Systems Design I

This three credit course provides an introduction to microprocessors. It uses assembly language to develop a foundation on the hardware, which executes a program. Memory and I/O interface design and programming. Study of microprocessor and its basic support components, including CPU architecture, memory interfaces and management, coprocessor interfaces, bus concepts, serial I/O devices, and interrupt control devices. Laboratories directly related to microprocessor functions and its interfaces. Prerequisites: EECE.2650 and EECE.3650.

EECE.3220 Data Structures and Algorithms

Introduction to object-oriented programming using C++, including: C++ input/output operators, default arguments, function overloading, strings, classes, dynamic memory allocation, and templates, Covers algorithms and their performance analysis, data structures, abstraction, and encapsulation. Introduces structures and their physical storage representation. Studies vectors, stacks, queues, linked lists, trees, graphs, heaps, priority queues, and hashing. Discusses efficient sorting (quicksort and heapsort) and introduces experimental analysis of algorithms as applied to engineering applications. Examines several design issues, including selection of data structures based on what operations need to be optimized (insertion, deletion, traversal, searching, sorting, evaluation), encapsulation of algorithms using class and template techniques, and how and when to use recursion (versus explicit stack-based techniques). Laboratories include programming of data structures in C++ applied to Engineering. Prerequisite: EECE.2160.

EECE.3330 Electronic Materials

The production and processing of materials into finished products constitutes a large part of the present economy. To prepare students for to use of a variety of traditional and new materials, this course will cover: atomic structure and chemical bonding, crystal geometry and defects, mechanical properties and phase diagrams of metals and alloys, electrical and optical properties of semiconductors, ceramics and polymers; brief description of electronic, quantum electronic and photonic devices; benefits and difficulties of materials design with decreasing dimensions from millimeters to micrometers and to nanometers. Prerequisites: MATH.1320 and PHYS.1440.

EECE.3550 Electromechanics

Alternating current circuits, three phase circuits, basics of electromagnetic field theory, magnetic circuits, inductance, electromechanical energy conversion. Ideal transformer, iron-core transformer, voltage regulation, efficiency equivalent circuit, and three phase transformers. Induction machine construction, equivalent circuit, torque speed characteristics, and single phase motors. Synchronous machine construction, equivalent circuit, power relationships phasor diagrams, and synchronous motors. Direct current machines construction, types, efficiency, power flow diagram, and external characteristics. Prerequisites: EECE.2020 and PHYS.1440.

EECE.3600 Engineering Electromagnetics I

Waves and Phasors, Transmission lines as Distributed Circuits, Smith Chart Calculations, Impedance Matching, Transients on Transmission Lines, Vector Analysis, Electrostatics and Capacitance, Steady current flow in conductors and Resistance, Magnetostatics and Inductance. Prerequisite: EECE.2020.

EECE.3620 Signals & Systems

A study of various continuous voltage/current time functions and their applications to linear time-invariant electrical systems. Review of pertinent topics from EECE.202 such as system functions, S-plane concepts and complete responses. Step, ramp and impulse responses of linear circuits. Sifting integrals. Types of analog filter responses. Designs for Butterworth and Chebyshev filters. Fourier Analysis, Fourier Transforms, Convolution, Laplace Transforms, Parseval's Theorem. Prerequisites: EECE.2020 and MATH.2360.

EECE.2140 Fundamentals of Sound Recording
Similar to EECE.2110 but tailored for Sound Recording Technology students only.

EECE.2160 ECE Application Programming
Introduces C programming for engineers. Covers fundamentals of procedural programming with applications in Electrical and Computer Engineering and embedded systems. Topics include variables, expressions and statements, console input/output, modularization and functions, arrays, pointers and strings, algorithms, structures, and file input/output. Introduces working with C at the bit manipulation level. Laboratories include designing and programming engineering applications. Prerequisite: ENGN.1080.

EECE.2330 Principles and History of Radio
Intended primarily for students majoring in the liberal arts. The course develops the theory of electricity from an historical perspective. Sufficient background in circuit theory, resonance, field theory and radio waves is given to provide an understanding of the principles of radio from its antecedents in the nineteenth century through the invention of the transistor in the mid twentieth century. The fundamental contributions of, for example Volta, Oersted, Morse, Maxwell, Faraday, Hertz, Lodge, and Marconi are considered. In the present century the technical advances of such figures as de Forest, Fleming, Fessenden, Armstrong and Shockley are studied. The growth, regulation and culture of American broadcasting are also central to the course. Laboratory work is required and students may use this course toward fulfilling the General Education (science/ experimental component) requirement of the University. Not open to students in the College of Engineering. Prerequisite: none.

EECE 2460 - Introduction to Data Communication Networks
This course is designed to convey the essentials of data communication and networking. This includes an understanding of the Open Systems Interconnection (OSI), TCP/IP and Internet models. It covers various protocols and architectures of interconnection technologies. Several concepts will be discussed that will enable students to apply the basic concepts of data communication and networking technology in many practical situations. Prerequisite: EECE.1070 Introduction to Electrical and Computer Engineering, and MATH.1310 Calculus I, and PHYS.1410 Physics I.

EECE.2650 Logic Design
Number systems and computer codes. Switching algebra. Canonical and fundamental forms of switching functions. Minimization of switching functions. Two-level and multi-level digital circuits. Decoder, encoders, multiplexers, and demultiplexers. Design of combinational circuits using SSI, MSI and programmable logic devices. Latches and flip-flops. Registers and counters. Analysis and synthesis of synchronous sequential circuits. Design of more complex circuits: data path and control. Prerequisite: ENGN.1080 and a grade of C- or better in MATH.1320, or COMP.1020.

EECE.3110 Electronics I Laboratory
Laboratory experiments coordinated with the subject matter of EECE.3650. Characteristics and use of electronic instrumentation for making measurements on electronic circuits. Methods of designing and characterizing diode and transistor circuits. Analysis of performance characteristics of digital and linear semiconductor circuits, including logic elements and amplifiers. Design and construction of circuits using monolithic op amps. Co-requisite: EECE.3650.

EECE.3120 Electronics II Laboratory
Laboratory experiments coordinated with the subject matter of EECE.366. High-frequency characteristics of transistors and transistor amplifiers. Feedback in electronic circuits. Electronic oscillators. Differential amplifiers. Properties of linear IC operational amplifiers and their application in amplifier circuits and waveform generation circuits. Linear circuit design and analysis. Prerequisite: EECE.3110. Co-requisite: EECE.3660.

Nanotechnology Certificate
Civil & Environmental, Mechanical, Plastics Engineering Departments
Contact: Dr. Jackie Zhang, 978-934-2287. jackie_zhang@uml.edu

The program will provide students with a fundamental knowledge of nanotechnology and is intended to respond to the increasing demand for trained professionals in Nano-science and technology. The certificate is designed for students with a background in chemistry, physics, biology, or any branch of engineering who want nanotechnology and Nano manufacturing workforce preparation. Students may focus on a concentration area based on their interests and background. Courses in each con- centration area are carefully designed to provide both analytical and practical competence. Students may take any combination from the electives list.

Core Courses – Required:
- ENGN.5500   Introduction to Nanotechnology

Core Courses (Choose one):
- CHEN.5410   Nanostructural Characterization by SEM, TEM, and AFM
- CHEM.5100   Electron Microscopy of Advanced Materials
- CHEM.5250   Analysis of Advanced Materials

Elective Courses (choose two courses):

Materials
- CHEN.5270   Nanomaterials Science and Engineering
- CHEN.5060   Interfacial Science and Engineering and Colloids
- MECH.5910 Mechanical Behavior of Materials
- PLAS.5130   New Plastics Materials
- PLAS.5980   Smart Polymers

Manufacturing
- CHEN.5230   Electronic Materials Processing
- CHEN.5350   Cell & Microbe Cultivation
- CHEN.5450   Isolation & Purification of Biotech Products
- EECE.5040   VLSI Fabrication
- PLAS.5020   New Plastics Processing Techniques
- PLAS.5780   Advanced Polymer Processing
- xxxx.xxxxx   Processing of Nanocomposites

Design and Devices
- EECE.7100   Special Topics in ECE: Nanoelectronics
- EECE.5020   VSLI Design
- EECE.5120   Electronic Materials
- EECE.5080   Quantum Electronics for Engineers

Health and Environmental Impacts
- PUBH.5140   Aerosol Science
- PUBH.5250   Industrial Hygiene and Ergonomics
- PUBH.5570   Toxic Use Reduction
- PUBH.6100   Exposure Assessment
- PUBH.6170   Measurements of Airborne Contaminants
- PUBH.5030   Toxicology and Health

Photonics & Opto-Electronic Devices Certificate
Physics Department and Electrical & Computer Engineering Department
Contact: Dr. James Egan, 978-934-3774 / 978-934-3300, james_egan@uml.edu

The certificate is offered jointly by the Electrical & Computer Engineering & Physics Departments and reflects the strong interests in the physics and technologies of electro-optics. Extensive research facilities include: new materials growth (molecular beam epitaxy) and device fabrication and testing laboratories.

Required Courses:
- PHYS.5770   Solid State Electronic & Opto-electronic Devices

  and
- PHYS.5390   Electro-optics

OR
- EECE.5950   Solid State Electronics and
- EECE.5680   Electro Optics and Integrated Optics

Elective Courses: (choose two of the following):
- EECE.5070   Electromagnetic Waves and Materials
- EECE.5080   Quantum Electronics for Engineers
- EECE.5900   Fiber Optic Communications
- EECE.6070   Electromagnetics of Complex Media
- EECE.6690   Opto Electronic Devices
- PHYS.5470   Laser Physics & Applications
- PHYS.6310   Nonlinear Optics
- PHYS.5780   Integrated Optics: Wave Guides & Lasers

Telecommunications Certificate
Computer Science Department
Contact: Dr. Byung Kim, 978-934-3617, Byung_Kim@uml.edu

The graduate certificate consists of courses from both the Computer Science and Electrical Engineering Departments. It is intended for students who hold a baccalaureate degree in science or engineering and who wish to concentrate on hardware/software issues pertaining to telecommunications.

Required Courses:
- EECE.5430   Theory of Communication
- COMP.5550   Computer Networks
- COMP.5630   Data Communications I

Plus, One Approved Elective

Electrical Engineering Course Descriptions

Undergraduate Courses

EECE.1000 Introduction to Electrical and Computer Engineering
This introductory course is designed to expose students to many of the new developments in Electrical and Computer Engineering, especially those ongoing in the Department. It will also provide information about co-op opportunities and career planning, while also allowing faculty in the Department to describe their courses and answer questions. Prerequisite: none.

EECE.2010 Circuit Theory I
Terminal characteristics of ideal elements, active and passive. Ohm's law and Kirchhoff's Laws. Introduction to network topology, independent variables, loop and nodal analysis with matrix methods. Definition and consequences of linearity. Superposition theorem. Concept of excitation and response. Passive equivalent circuits; active equivalent circuits. Thevenin's and Norton's theorems. Ideal inductance and capacitance, volt-ampere characteristics, energy relations, First-order transients: initial conditions, natural response, and natural frequencies. Network response to unit step function and unit impulse. Second-order transients: RLC circuits, natural frequencies and the complex-frequency s-plane. Introduction to matrices and their use in circuit analysis. Prerequisite: GPA at least 2.000, MATH.1320 Grade "C" or better, Co-requisite: EECE.2070.

EECE.2020 Circuit Theory II
Sinusoidal forcing function, complex numbers, phasors, sinusoidal steady-state conditions. Impedance, average real power, reactive power and rms values. Exponential forcing function, poles and zeros in the s-plane, concept of the system function and its use in determining the forced response and natural behavior of circuits. Frequency response and resonance, reactance cancellation and concept of s-plane vectors. Thevenin's and Norton's theorems, superposition, reciprocity, and maximum power in the frequency domain. Impedance and admittance and hybrid parameters for a two-port network. Magnetic coupling, mutual inductance, ideal transformer. Prerequisite: EECE.2010. Co- requisite: EECE.2080.

EECE.2070 Basic EE I Laboratory
Experimental work designed to verify theory and to acquaint students with electrical measurement techniques: experiments on meters, bridges, and oscilloscopes. Experiments are correlated with course EECE.2010 and concern: resistive measurements, Kirchhoff's laws, network theorems, conservation of power and maximum power transfer, inductance and capacitance, and first and second-order transients, operational amplifiers. Co-requisite: EECE.2010.

EECE.2080 Basic EE II Laboratory
Experimental work, designed to emphasize electrical measurement techniques of linear systems with time-varying signals. Waveform measurements with ac meters as well as advanced use of the digital oscilloscope. Experiments are integrated with course EECE.202. Experiments cover: Kirchhoff's laws for phasors, magnitude and phase measurements of impedance, network theorems, frequency response, pole and zero location, resonance, inductance, statistical variation of components, modeling with MATLAB. Prerequisite: EECE.2070. Co-requisite: EECE.2020.

EECE.2110/2130 Fundamentals of Electricity
An introduction to direct current and alternating current analysis of electric circuits, with emphasis on energy and power. Design and use of multirange voltmeters, ammeters, and ohmmeters. Use of bridges and oscilloscopes. Phasor analysis of AC circuits, Trigonometric Fourier series, and BODE plots. Transformers, relays, and solenoids. DC and AC motors and generators. Semiconductor devices: p-n junctions, diodes, Zener diodes, bipolar transistors, JFETs, MOSFETs. Amplifiers. Operational amplifiers and their applications. Introduction to digital logic including minimization techniques. Not for ECE majors. Prerequisite: MATH.1320.

EECE.2120 Fundamentals of Electricity Laboratory
Laboratory for EECE.2110/2130. Experiments designed to correlate with the topics covered in the course EECE.211. Reinforcement of various concepts through measurement techniques. Experiments cover: measurement of current and voltage, series and parallel DC circuits; superposition theorem, Thevenin's theorem, use of oscilloscope, impedance measurements of RLC, frequency response of RL, RC networks, diode operations, clipper actions, rectifiers and operational amplifiers. Co-requisite: EECE.4000.